

(19) World Intellectual Property Organization  
International Bureau(43) International Publication Date  
28 June 2001 (28.06.2001)(10) International Publication Number  
WO 01/45485 A2

(51) International Patent Classification: Not classified (81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(21) International Application Number: PCT/SE01/00229 (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

(22) International Filing Date: 7 February 2001 (07.02.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
09/501,235 10 February 2000 (10.02.2000) US  
09/501,571 10 February 2000 (10.02.2000) US

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**Published:**

- Upon request of the applicant, before the expiration of the time limit referred to in Article 21(2)(a).
- Without international search report and to be republished upon receipt of that report.
- Without classification; title and abstract not checked by the International Searching Authority.

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 01/45485 A2

**(54) Title: CONTROLLED HEARTBURN AND REFLUX DISEASE TREATMENT APPARATUS**

(57) **Abstract:** A heartburn and reflux disease treatment apparatus comprises a restriction device (56) implantable in a patient for engaging the stomach close to the cardia or, which is preferred, engaging the esophagus (58) to form a restricted food passageway in the stomach or esophagus. The restriction device is operable by an implantable operation device (60) to change the restriction of the food passageway. A control device (62 and 64) is provided for controlling a source of energy, which may or may not be implanted, from outside the patient's body, to release energy for use in connection with the operation of the restriction device, i.e. to power the operation device.

CONTROLLED HEARTBURN AND REFLUX DISEASE TREATMENT APPARATUS

The present invention relates to a heartburn and reflux disease treatment apparatus, comprising a restriction device implantable in a patient, who suffers from heartburn and reflux disease, for engaging the stomach close to the cardia or engaging the esophagus, to form a restricted food passageway in the stomach or esophagus. The term "patient" includes an animal or 10 a human being.

Heartburn and reflux disease is a widespread medical problem. This is often due to hiatal hernia, i.e. a portion of the stomach immediately below the gastric fundus slides upwardly through the esophageal hiatus. In consequence, stomach acids and 15 foods are regurgitated into the esophagus.

In the late 1970s a prior art restriction device called Angelchik, according to U.S. Patent No. 3,875,928, was used to operatively treat heartburn and reflux disease. However, the Angelchik restriction device had a major disadvantage in that it 20 was not possible to adjust the size of the restriction opening after the operation. A further disadvantage was that the restriction device did not satisfactorily protect the esophagus and the surrounding area against injuries due to poor shape of the restriction device. Therefore, operations using the Angelchik 25 restriction device are no longer practised.

An operation technique, semi-fundoduplicatio, is currently in use for treating heartburn and reflux disease. A most common operation is Nissen semi-fundoduplicatio, in which one takes the fundus of the stomach and makes a three quarter of a turn around 30 the esophagus and suture between the stomach and esophagus. Although this operation works fairly well it has three main disadvantages. Firstly, most patient's treated in accordance to

"ad modum Nissen" lose their ability to belch. Secondly, many of these patient's get dysphagia, i.e. difficulties to swallow after the operation. Thirdly, it is not possible to adjust the food passageway in the esophagus or stomach in any way after the 5 operation. Characteristic for these patient's is the variation of their problems over the day. For example, many patient's have difficulties during the night when they lie down because of stomach acid leaking up into the esophagus.

10 It is an object of the present invention to provide a new convenient heartburn and reflux disease treatment apparatus, the performance of which may be affected by the patient at any time after operation, in particular when various needs arise over the day, so that the patient always is satisfied.

15 This object is achieved by a heartburn and reflux disease treatment apparatus of the kind stated initially, which is characterised in that the restriction device is operable to change the restriction of the restricted food passageway, a source of energy is provided, and a control device operable from 20 outside the patient's body is provided for controlling the source of energy to release energy for use in connection with the operation of the restriction device, when the restriction device is implanted.

As a result, the advantage is achieved that the restriction 25 device can be non-invasively operated, when the restriction device has to be adjusted. Furthermore, the apparatus of the invention provides a simple and effective control of the energy supplied to implanted components of the apparatus which ensures an extended and reliable functionality of the apparatus, possibly 30 for the rest of the patient's life and at least many years.

The control device may also control the restriction device. The control device may comprise an internal control unit,

preferably including a microprocessor, implantable in the patient for controlling the restriction device. The control device may further comprise an external control unit outside the patient's body, wherein the internal control unit is programmable by the 5 external control unit, for example for controlling the restriction device over time. Alternatively, the internal control unit may control the restriction device over time in accordance with an activity schedule program, which may be adapted to the patient's needs.

10 A great advantage is that the patient is enabled to adjust the restriction of the food passageway by using the control device whenever he likes during the day. This advantage should not be underestimated, because in case the patient would need to vomit it would be very difficult for him to do so if he were 15 unable to immediately enlarge the food passageway.

Conveniently, the external control unit may load the internal control unit with data in accordance with a loading mode only authorized for a doctor. For specialized controls of the restriction device, the external control unit may control the 20 internal control unit in accordance with a doctor mode only authorized for the doctor. For simple controls of the restriction device, the external control unit may control the internal control unit in accordance with a patient mode permitted for the patient. Thus, by using the external control unit in accordance 25 with different modes it is possible to have certain functions of the restriction device controlled by the patient and other more advanced functions controlled by the doctor, which enables a flexible post-operation treatment of the patient.

The control device may be adapted to control the source of 30 energy to release energy, for instance to intermittently release energy in the form of a train of energy pulses, for direct use in connection with the operation of the restriction device. In

accordance with a suitable embodiment the control device controls the source of energy to release electric energy, and the apparatus further comprises an implantable capacitor for producing the train of energy pulses from the released energy.

5 In this case the term "direct" is used to mean, on one hand, that the released energy is used while it is being released by the control device, on the other hand, that the released energy may be somewhat delayed, in the order of seconds, by for instance an energy stabilizer before being used in connection with the 10 operation of the restriction device. The restriction device may be operable in non-manual, a non-magnetic or non-mechanical manner by use of the released energy.

In accordance with a preferred embodiment of the invention, the apparatus comprises implantable electrical components 15 including at least one, or only one single voltage level guard and a capacitor or accumulator, wherein the charge and discharge of the capacitor or accumulator is controlled by use of the voltage level guard. As a result, there is no need for any implanted current detector and/or charge level detector for the 20 control of the capacitor, which makes the apparatus simple and reliable.

Generally, the apparatus further comprises an operation device implantable in the patient for operating the restriction device, wherein the control device controls the operation device 25 to operate the restriction device. The control device may directly power the operation device with energy released from the source of energy and/or power other implantable energy consuming components of the apparatus. In this case the term "directly" is used to mean, on one hand, that the operation device is powered 30 with released energy while the latter is being released by the control device, on the other hand, that the released energy may be somewhat delayed, in the order of seconds, by for instance an

energy stabilizer before powering the operation device. The advantage of directly using energy as it is released is that the apparatus can be of a very simple design and the few components involved makes the apparatus extremely reliable.

5 The restriction device may be non-inflatable, i.e. with no hydraulic fluid involved for the adjustments of the restriction device. This eliminates problems with fluid leaking from the restriction device.

10 The operation device may comprise hydraulic means and at least one valve for controlling a fluid flow in the hydraulic means. The control device may suitably comprise a wireless remote control for controlling the valve. The restriction device may comprise hydraulic means and the operation device may comprise a reservoir forming a fluid chamber with a variable volume 15 connected to the hydraulic means. The operation device may distribute fluid from the chamber to the hydraulic means by reduction of the volume of the chamber and withdraw fluid from the hydraulic means to the chamber by expansion of the volume of the chamber.

20 In accordance with a first main aspect of the invention, the source of energy is external to the patient's body and the control device controls the source of energy to release wireless energy. The external source of energy may be of any conceivable kind, such as a nuclear source of energy or a chemical source of 25 energy.

An energy storage device, preferably an electric accumulator, may be implantable in the patient for storing the wireless energy released from the external source of energy. The electric accumulator may comprise at least one capacitor or at 30 least one rechargeable battery, or a combination of at least one capacitor and at least one rechargeable battery. Alternatively, a battery may be implantable in the patient for supplying

electric energy to implanted electric energy consuming components of the apparatus, in addition to the supply of wireless energy. Where the control device comprises an implantable control unit the electronic circuit thereof and the 5 restriction device may be directly powered with transformed wireless energy, or energy from either the implantable energy storage device or battery.

In accordance with a second main aspect of the invention, the wireless energy is directly used for operation of the 10 restriction device, i.e. the restriction device is operated as the wireless energy is released from the external source of energy by the control device. In this case the term "directly" is used to mean, on one hand, that the restriction device is promptly operated by using the released energy without first 15 storing the latter, on the other hand, that the released energy may be somewhat delayed, in the order of seconds, by for instance an energy stabilizer before being used for the operation of the restriction device. As a result, a very simple control of the restriction device is achieved and there are only a few implanted 20 components of the apparatus. For example, there is no implanted source of energy, such as a battery, nor any implanted complicated signal control system. This gives the advantage that the apparatus will be extremely reliable.

Generally, the control device controls and directly or 25 indirectly powers the operation device with wireless energy released from the source of energy and/or powers other implanted energy consuming components of the apparatus.

In a first particular embodiment in accordance with the first and second main aspects of the invention, the operation 30 device comprises a motor, preferably an electric motor which may have electrically conductive parts made of plastics. The motor may include a rotary motor, wherein the control device is adapted

to control the rotary motor to rotate a desired number of revolutions. Alternatively, the motor may include a linear motor, or a hydraulic or pneumatic fluid motor, wherein the control device is adapted to control the fluid flow through the fluid motor. Motors currently available on the market are getting smaller and smaller. Furthermore, there is a great variety of control methods and miniaturized control equipment available. For example, a number of revolutions of a rotary motor may be analyzed by a Hall-element just a few mm in size.

In a second particular embodiment in accordance with the first and second main aspects of the invention, the control device is adapted to shift polarity of the released energy to reverse the operation device. The operation device may suitably comprise an electric motor and the released energy may comprise electric energy.

In a third particular embodiment in accordance with the first and second main aspects of the invention, the restriction device is operable to perform a reversible function and there is a reversing device implantable in the patient for reversing the function performed by the restriction device. Such a reversing function preferably involves enlarging and restricting the food passageway by the restriction device, suitably in a stepless manner. In this connection, the control device suitably controls the reversing device, which may include a switch, to reverse the function performed by the restriction device. The reversing device may comprise hydraulic means including a valve for shifting the flow direction of a fluid in the hydraulic means. Alternatively, the reversing device may comprise a mechanical reversing device, such as a switch or a gearbox.

Where the reversing device comprises a switch the control device suitably controls the operation of the switch by shifting polarity of released energy supplied to the switch. The switch

may comprise an electric switch and the source of energy may supply electric energy for the operation of the switch. The switch mentioned above may comprise an electronic switch or, where applicable, a mechanical switch.

5 In accordance with the third particular embodiment, the operation device preferably comprises a motor, wherein the reversing device reverses the motor.

In a fourth particular embodiment in accordance with the first and second main aspects of the invention, the restriction 10 device comprises hydraulic means, for example including an expandible/contractible cavity for fluid. Preferably, the operation device is adapted to conduct hydraulic fluid in the hydraulic means, and comprises a motor, a valveless fluid conduit connected to the hydraulic means of the restriction device, and 15 a reservoir for fluid, wherein the reservoir forms part of the conduit. The operation device suitably comprises a pump operated by the motor. All of the hydraulic components involved are preferably devoid of any non-return valve. This is of great advantage, because with valves involved there is always a risk 20 of malfunction due to improperly working valves, especially when long time periods passes between valve operations. The reservoir may form a fluid chamber with a variable volume, and the pump may distribute fluid from the chamber to the hydraulic means of the restriction device by reduction of the volume of the chamber and 25 withdraw fluid from the hydraulic means to the chamber by expansion of the volume of the chamber.

In accordance with a third main aspect of the invention, the source of energy is implantable in the patient. Thus, when the source of energy is implanted in a patient the control device 30 controls it from outside the patient's body to release energy. This solution is advantageous for embodiments of the apparatus that have a relatively high consumption of energy which cannot

be satisfied by direct supply of wireless energy.

The implantable source of energy may comprise an accumulator, preferably an electric source of energy, such as a battery having a lifetime of at least 10 years.

5        In accordance with a fourth main aspect of the invention, the apparatus comprises a switch implanted in the patient for directly or indirectly switching the operation of the restriction device and an internal source of energy, such as a battery, implanted in the patient for supplying energy for the operation 10 of the restriction device, wherein the switch directly or indirectly affects the supply of energy from the internal source of energy. This solution is advantageous for embodiments of the apparatus that have a relatively high energy consumption which cannot be met by direct supply of wireless energy.

15        In a first particular embodiment in accordance with the fourth main aspect of the invention, the switch switches between an off mode, in which the internal source of energy is not in use, and an on mode, in which the internal source of energy supplies energy for the operation of the restriction device. In 20 this case, the switch is conveniently operated by the wireless energy released from the external source of energy to switch between the on and off modes. The control device, preferably comprising a wireless remote control, may control the external source of energy to release the wireless energy. The advantage 25 of this embodiment is that the lifetime of the implanted source of energy, such as a battery, can be significantly prolonged, since the implanted source of energy does not supply energy when the switch is in its off mode.

30        In a second particular embodiment in accordance with the fourth main aspect of the invention, the control device comprises a wireless remote control for controlling the internal source of energy. In this case, the switch is operable by the wireless

energy from the external source of energy to switch between an off mode, in which the internal source of energy and remote control are not in use, and a standby mode, in which the remote control is permitted to control the internal source of energy to supply energy for the operation of the restriction device.

In a third particular embodiment in accordance with the fourth main aspect of the invention, the apparatus further comprises an energy transforming device implanted in the patient for transforming the wireless energy into storable energy, wherein the internal source of energy is capable of storing the storable energy. The internal source of energy preferably comprises an electric accumulator, at least one capacitor or at least one rechargeable battery, or a combination of at least one capacitor and at least one rechargeable battery. In this case, the switch switches from an off mode, in which the internal source of energy is not in use, to an on mode, in which the internal source of energy supplies energy for the operation of the restriction device.

The control device, preferably comprising a wireless remote control, may control the switch to switch between the on and off modes.

Alternatively, in this third particular embodiment an energy storage device may be implanted in the patient for storing the storable energy instead of the internal source of energy, wherein the switch is operable by energy from the implanted energy storage device to switch between an off mode, in which the internal source of energy is not in use, and an on mode, in which the internal source of energy supplies energy for the operation of the restriction device. In this case, the control device (the wireless remote control) controls the energy storage device to operate the switch.

The internal source of energy preferably comprises an

electric source of energy, such as an accumulator or a battery having a lifetime of at least 10 years. However, other kinds of sources are also conceivable, such as a nuclear source of energy or a chemical source of energy.

5 The above first, second, third and fourth particular embodiments described in connection with the first and second main aspects of the invention are also applicable in accordance with the third main aspect of the invention, i.e. where the source of energy is implantable, and in accordance with the 10 fourth main aspect of the invention, i.e. where the apparatus comprises an implantable switch.

All of the above embodiments may be combined with at least one implantable sensor for sensing at least one physical parameter of the patient, wherein the control device may control 15 the restriction device in response to signals from the sensor. For example, the sensor may comprise a pressure sensor for directly or indirectly sensing the pressure in the food passageway. The expression "*indirectly sensing the pressure in the food passageway*" should be understood to encompass the cases 20 where the sensor senses the pressure against the restriction device or human tissue of the patient. Where the control device comprises an internal control unit to be implanted in the patient, the internal control unit may suitably directly control the restriction device in response to signals from the sensor. 25 In response to signals from the sensor, for example pressure, the patient's position or any other important physical parameter, the internal control unit may send information thereon to outside the patient's body. The control unit may also automatically control the restriction device in response to signals from the sensor. 30 For example, the control unit may control the restriction device to further restrict the food passageway in the stomach in response to the sensor sensing that the patient is lying, or

enlarge the food passageway in response to the sensor sensing an abnormally high pressure against the restriction device.

Where the control device comprises an external control unit outside the patient's body, the external control unit may, 5 suitably directly, control the restriction device in response to signals from the sensor. The external control unit may store information on the physical parameter sensed by the sensor and may be manually operated to control the restriction device based on the stored information. In addition, there may be at least one 10 implantable sender for sending information on the physical parameter sensed by the sensor.

An external data communicator may be provided outside the patient's body and an internal data communicator to be implanted in the patient may be provided for communicating with the 15 external data communicator. The internal data communicator may feed data related to the patient, or related to the restriction device, back to the external data communicator. Alternatively or in combination, the external data communicator may feed data to the internal data communicator. The internal data communicator 20 may suitably feed data related to at least one physical signal of the patient.

Generally, the apparatus of the invention may comprise a switch implantable in the patient for directly or indirectly switching the energy released from the source of energy. For 25 example, the restriction device may be operable to open and close the food passageway or may steplessly control the cross-sectional area of the food passageway. A pressure sensor may be provided for directly or indirectly sensing the pressure in the food passageway. The control device may control the restriction device 30 in response to signals from the pressure sensor.

The apparatus may comprise an implantable energy transforming device, wherein the control device releases electric

energy and the energy transforming device transforms the electric energy into kinetic energy for, preferably direct, operation of the restriction device. Suitably, an implantable stabilizer, such as a capacitor or a rechargeable accumulator, 5 or the like, may be provided for stabilizing the electric energy released by the control device. In addition, the control device may control the source of energy to release energy for a determined time period or in a determined number of energy pulses. Finally, the restriction device may be non-inflatable.

10 All of the above embodiments are preferably remote controlled. Thus, the control device advantageously comprises a wireless remote control transmitting at least one wireless control signal for controlling the restriction device. With such a remote control it will be possible to adapt the function of the 15 apparatus to the patient's need in a daily basis, which is beneficial with respect to the treatment of the patient.

The wireless remote control may be capable of obtaining information on the condition of the restriction device and of controlling the restriction device in response to the 20 information. Also, The remote control may be capable of sending information related to the restriction device from inside the patient's body to the outside thereof.

In a particular embodiment of the invention, the wireless remote control comprises at least one external signal transmitter 25 or transceiver and at least one internal signal receiver or transceiver implantable in the patient. In another particular embodiment of the invention, the wireless remote control comprises at least one external signal receiver or transceiver and at least one internal signal transmitter or transceiver 30 implantable in the patient.

The remote control may transmit a carrier signal for carrying the control signal, wherein the carrier signal is

frequency, amplitude or frequency and amplitude modulated and is digital, analog or digital and analog. Also the control signal used with the carrier signal may be frequency, amplitude or frequency and amplitude modulated.

5 The control signal may comprise a wave signal, for example, a sound wave signal, such as an ultrasound wave signal, an electromagnetic wave signal, such as an infrared light signal, a visible light signal, an ultra violet light signal, a laser signal, a micro wave signal, a radio wave signal, an x-ray 10 radiation signal, or a gamma radiation signal. Where applicable, two or more of the above signals may be combined.

The control signal may be digital or analog, and may comprise an electric or magnetic field. Suitably, the wireless remote control may transmit an electromagnetic carrier wave 15 signal for carrying the digital or analog control signal. For example, use of an analog carrier wave signal carrying a digital control signal would give safe communication. The control signal may be transmitted in pulses by the wireless remote control.

In all of the above solutions, the control device 20 advantageously releases energy from the source of energy in a non-invasive, magnetic, non-magnetic, mechanical or non-mechanical manner.

The control device may release magnetic, electromagnetic, kinetic, sonic or thermal energy, or non-magnetic, non-sonic, 25 non-thermal, non-electromagnetic or non-kinetic energy.

The control device may be activated in a manual or non-manual manner to control the source of energy to release energy.

The operation device may be powered by magnetic energy, non-magnetic energy, electromagnetic energy, non-electromagnetic 30 energy, kinetic energy, non-kinetic energy, thermal energy or non-thermal energy. However, preferably the operation device comprises an electrical operation device.

Typically the apparatus of the invention comprises an adjustment device for adjusting the restriction device to change the restriction of the food passageway. The adjustment device may be adapted to mechanically adjust the restriction device.

5 Alternatively, the adjustment device may be adapted to hydraulically adjust the restriction device by using hydraulic means which is devoid of hydraulic fluid of the kind having a viscosity that substantially increases when exposed to heat or a magnetic field, i.e. the hydraulic fluid would not become more 10 viscous when exposed to heat or influenced by magnetic forces.

The above-presented embodiments of the invention may be modified in accordance with the following suggestions. The released energy may comprise electric energy and an implantable capacitor having a capacity less than 0,1  $\mu$ F may be provided for 15 producing the above-mentioned train of energy pulses.

An implantable motor or pump may be provided for operating the restriction device, wherein the control device is adapted to control the source of energy to directly power the motor or pump with the released energy. Specifically, the control device may 20 be adapted to release wireless energy in the form of a magnetic field or electromagnetic waves (excluding radio waves) for direct power of the motor or pump, as the wireless energy is being released. Where a pump is used it preferably is not a plunger type of pump.

25 Generally, the wireless energy comprises a signal.

The apparatus may further comprise implantable energy transforming device for transforming wireless energy directly or indirectly into energy different than the wireless energy, for operation of the restriction device. For example, the motor or 30 pump may be powered by the transformed energy.

The energy transforming device may transform the wireless energy in the form of sound waves, preferably directly, into

electric energy for operation of the restriction device. The energy transforming device may comprise a capacitor adapted to produce electric pulses from the transformed electric energy.

The motor mentioned in the present specification may also 5 be directly powered with wirelessly transmitted electromagnetic or magnetic energy in the form of signals, as the energy is transmitted. Furthermore, all the various functions of the motor and associated components described in the present specification may be used where applicable.

10 Generally, the restriction device advantageously is embedded in a soft or gel-like material, such as a silicone material having hardness less than 20 Shore.

Of course, the restriction device preferably is adjustable in a non-manual manner.

15 All the above described various components, such as the motor, pump and capacitor, may be combined in the different embodiments where applicable. Also the various functions described in connection with the above embodiments of the invention may be used in different applications, where 20 applicable.

All the various ways of transferring energy and controlling the energy presented in the present specification may be practised by using all of the various components and solutions described.

25 The present invention also provides methods for treating heartburn and reflux disease.

Accordingly, in accordance with a first alternative method, there is provided a method of treating heartburn and reflux disease, comprising the steps of implanting an operable 30 restriction device in a patient, so that the restriction device engages the stomach close to the cardia or engages the esophagus to form a restricted food passageway in the stomach or esophagus,

providing a source of energy for energizing the restriction device, and controlling the source of energy to release energy for use in connection with the operation of the restriction device. The method may further comprise using energy released 5 from the source of energy to operate the restriction device to enlarge and reduce, respectively, the food pasageway.

In accordance with a second alternative method, there is provided a method of treating heartburn and reflux disease, comprising the steps of placing at least two laparascopical 10 trocars in a patient's body, inserting a dissecting tool through the trocars and dissecting an area of the stomach or esophagus, placing an operable restriction device in the dissected area, so that the restriction device engages the stomach close to the cardia or engages the esophagus to form a restricted food 15 passageway in the stomach or esophagus, implanting a source of energy in the patient, and controlling the implanted source of energy from outside the patient's body to release energy for use in connection with the operation of the restriction device.

In accordance with a third alternative method, there is 20 provided a method of treating a human or animal having heartburn and reflux disease, comprising: (a) Surgically implanting in the human or animal an operable restriction device engaging the human's or animal's stomach, close to the cardia, or esophagus to form a restricted food passageway in the stomach or esophagus. 25 (b) Providing a source of energy external to the patient's body.

(c) Controlling the external source of energy from outside the patient's body to release wireless energy. And (d) using the released wireless energy in connection with the operation of the restriction device.

30 The third alternative method may further comprise (e) implanting in the human or animal an operation device which can adjust the restricted food passageway in response to supplied

energy, and (f) using the released wireless energy to activate the implanted operation device so as (i) to enlarge the restricted food passageway to allow food to readily pass therethrough into the human's or animal's stomach, or to allow 5 the human or animal to regurgitate, or (ii) to restrict the restricted food passageway sufficiently so as to substantially prevent regurgitation of stomach acids and foods into the esophagus. In the method (f) may be practiced at least once a day, normally several times (e.g. 2-10) a day.

10 In accordance with a fourth alternative method, there is provided a method of treating a human or animal having heartburn and reflux disease, comprising the steps of placing at least two laparascopical trocars in the human's or animal's body, inserting a dissecting tool through the trocars and dissecting an area of 15 the stomach or esophagus, placing an operable restriction device in the dissected area, so that the restriction device engages the stomach close to the cardia or engages the esophagus to form a restricted food passageway in the stomach or esophagus, providing an external source of energy outside the human's or animal's 20 body, controlling the external source of energy from outside the patient's body to release wireless energy, and using the released wireless energy in connection with the operation of the restriction device.

25 In accordance with a fifth alternative method, there is provided a method of treating a human or animal having heartburn and reflux disease, comprising the steps of placing at least two laparascopical trocars in the human's or animal's body, inserting a dissecting tool through the trocars and dissecting an area of the stomach or esophagus, implanting an operable restriction 30 device in the dissected area, so that the restriction device engages the stomach close to the cardia or engages the esophagus to form a restricted food passageway in the stomach or esophagus,

implanting an energy transforming device, providing an external source of energy, controlling the external source of energy to release wireless energy, and transforming the wireless energy by the energy transforming device into energy different from the 5 wireless energy for use in connection with the operation of the restriction device. This method may further comprise implanting a stabilizer in the human or animal for stabilizing the energy transformed by the energy transforming device.

10 The invention is described in more detail in the following with reference to the accompanying drawings, in which

FIGURES 1 to 6 are schematic block diagrams illustrating six embodiments, respectively, of the invention, in which wireless energy is released from an external source of energy;

15 FIGURES 7 to 10 are schematic block diagrams illustrating four embodiments, respectively, of the invention, in which energy is released from an implanted source of energy;

20 FIGURES 11 to 15 are schematic block diagrams illustrating five embodiments, respectively, of the invention, in which a switch is implanted in the patient for directly or indirectly switching the operation of the restriction device;

FIGURE 16 is a schematic block diagram illustrating conceivable combinations of implantable components for achieving various communication options;

25 FIGURE 17 illustrates the apparatus in accordance with the invention implanted in a patient;

FIGURE 18 is a block diagram illustrating remote control components of an embodiment of the invention; and

30 FIGURE 19 is a schematic view of exemplary circuitry used for the components of the block diagram of FIGURE 18.

Referring to the drawing figures, like reference numerals designate identical or corresponding elements throughout the

several figures.

FIGURE 1 schematically shows an embodiment of the heartburn and reflux disease apparatus of the invention having some parts implanted in a patient and other parts located outside the patient's body. Thus, in FIGURE 1 all parts placed to the right of the patient's skin 2 are implanted and all parts placed to the left of the skin 2 are located outside the patient's body. The apparatus of FIGURE 1 comprises an implanted operable restriction device 4, which engages the patient's stomach close to the cardia (or alternatively engages the esophagus) to form a restricted food passageway in the stomach. The restriction device 4 is capable of performing a reversible function, i.e. to enlarge and reduce the cross-sectional area of the food passageway, whereby 15 the restriction device works as an artificial sphincter. An implanted control unit 6 controls the restriction device 4 via a control line 8 to form an adequate size of the cross-sectional area of the restricted food passageway. An external control unit 10 includes an external source of energy and a wireless remote 20 control transmitting a control signal generated by the external source of energy. The control signal is received by a signal receiver incorporated in the implanted control unit 6, whereby the control unit 6 controls the implanted restriction device 4 in response to the control signal. The implanted control unit 25 6 also uses energy from the control signal for operating the restriction device 4 via a power supply line 12.

FIGURE 2 shows an embodiment of the invention identical to that of FIGURE 1, except that a reversing device in the form of a switch 14 operable by energy also is implanted in the patient 30 for reversing the restriction device 4. The control unit 6 uses the switch 14 to reverse the function performed by the restriction device 4. More precisely, the external control unit

10 releases energy carried by a wireless signal and the implanted control unit 6 transforms the wireless energy into a current for operating the switch 14. When the control unit 6 shifts the polarity of the current the switch 14 reverses the function 5 performed by the restriction device 4.

FIGURE 3 shows an embodiment of the invention identical to that of FIGURE 1, except that an operation device in the form of a motor 16 also is implanted in the patient. The implanted control unit 6 powers the motor 16 with wireless energy released 10 from the external source of energy of the external control unit 10. The implanted control unit 6 controls the operation of the motor 16 in response to a control signal from the remote control of the external control unit 10.

FIGURE 4 shows an embodiment of the invention identical to 15 that of FIGURE 1, except that an assembly 16 including a motor/pump unit 18 and a fluid reservoir 20 also is implanted in the patient. In this case the restriction device 4 is hydraulically operated, i.e. hydraulic fluid is pumped by the motor/pump unit 18 from the reservoir 20 through a conduit 22 to 20 the restriction device 4 to reduce the cross-sectional area of the food passageway, and hydraulic fluid is pumped by the motor/pump unit 18 back from the restriction device 4 to the reservoir 20 to enlarge the cross-sectional area. The external control unit 10 releases energy carried by a wireless signal and 25 the implanted control unit 6 transforms the wireless energy into a current, for example a current, for powering the motor/pump unit 18 via an electric power supply line 24. The implanted control unit 6 controls the motor/pump unit 16 and the restriction device 4 via control lines 26 and 27.

30 FIGURE 5 shows an embodiment of the invention comprising the restriction device 4, hydraulically operated, and the implanted control unit 6, and further comprising a hydraulic fluid

reservoir 230, a motor/pump unit 232 and a reversing device in the form of a hydraulic valve shifting device 234, all of which are implanted in the patient. The motor of the motor/pump unit 232 is an electric motor.

5 FIGURE 6 shows an embodiment of the invention identical to that of FIGURE 1, except that an accumulator 28 also is implanted in the patient. The control unit 6 stores energy received from the external control unit 10 in the accumulator 28. In response to a control signal from the external control unit 10 the 10 implanted control unit 6 releases energy from the accumulator 28 via a power line 30 for the operation of the restriction device 4.

FIGURE 7 shows an embodiment of the invention comprising the restriction device 4, hydraulically operated, and the implanted 15 control unit 6, and further comprising a source of energy in the form of a battery 32, a hydraulic fluid reservoir 34, a motor/pump unit 36 and a reversing device in the form of a hydraulic valve shifting device 38, all of which are implanted in the patient. The motor of the motor/pump unit 36 is an 20 electric motor. An external control unit 40 includes a wireless remote control transmitting a control signal which is received by the signal receiver incorporated in the implanted control unit 6.

In response to a control signal from the external control 25 unit 40 the implanted control unit 6 powers the motor/pump unit 36 with energy from the battery 32, whereby the motor/pump unit 36 distributes hydraulic fluid between the reservoir 34 and the restriction device 4. The control unit 6 controls the shifting device 38 to shift the hydraulic fluid flow direction between one 30 direction in which the fluid is pumped by the motor/pump unit 36 from the reservoir 34 to the restriction device 4 to reduce the cross-sectional area of the food passageway, and another opposite

direction in which the fluid is pumped by the motor/pump unit 36 back from the restriction device 4 to the reservoir 34 to enlarge the cross-sectional area.

FIGURE 8 shows an embodiment of the invention identical to that of FIGURE 6, except that a battery 42 is substituted for the accumulator 28, the external control unit 40 of the embodiment of FIGURE 5 is substituted for the external control unit 10 and an electric motor 44 is implanted in the patient for operating the restriction device 4. In response to a control signal from the external control unit 40 the implanted control unit 6 powers the motor 44 with energy from the battery 42, whereby the motor 44 operates the restriction device 4.

FIGURE 9 shows an embodiment of the invention identical to that of FIGURE 8, except that the motor/pump unit 36 of the embodiment of FIGURE 7 is substituted for the motor 44 and a fluid reservoir 46 also is implanted in the patient. The reservoir 46 is via fluid conduits 48 and 50 connected to the motor/pump unit 36 and restriction device 4, which in this case is hydraulically operated. In response to a control signal from the external control unit 40, the implanted control unit 6 powers the electric motor of the motor/pump unit 36 with energy from the battery 42, whereby the motor/pump unit 36 distributes hydraulic fluid between the fluid reservoir 46 and the restriction device 4.

FIGURE 10 shows an embodiment of the invention identical to that of FIGURE 8, except that a mechanical reversing device in the form of a gearbox 52 also is implanted in the patient. The implanted control unit 6 controls the gearbox 52 to reverse the function performed by the restriction device 4 (mechanically operated).

FIGURE 11 shows an embodiment of the invention comprising the restriction device 4, the external control unit 10, an

implanted source of energy 236 and an implanted switch 238. The switch 238 is operated by wireless energy released from the external source of energy of the external control unit 6 to switch between an off mode, in which the implanted source of energy 236 is not in use, and an on mode, in which the implanted source of energy 236 supplies energy for the operation of the restriction device 4.

FIGURE 12 shows an embodiment of the invention identical to that of FIGURE 11, except that also the control unit 6 is implanted, in order to receive a control signal from the wireless remote control of the external control unit 10. The switch 238 is operated by the wireless energy from the external source of energy 10 to switch between an off mode, in which the implanted source of energy 236 and the wireless remote control of the external control unit 10 are not in use, i.e. the control unit 6 is not capable of receiving the control signal, and a standby mode, in which the wireless remote control is permitted to control the internal source of energy 236, via the implanted control unit 6, to supply energy for the operation of the restriction device 4.

FIGURE 13 shows an embodiment of the invention identical to that of FIGURE 12, except that an energy transforming device for transforming the wireless energy into storable energy is incorporated in the implanted control unit 6 and that the implanted source of energy 236 is of a type that is capable of storing the storable energy. In this case, in response to a control signal from the external control unit 10, the implanted control unit 6 controls the switch 238 to switch from an off mode, in which the implanted source of energy 236 is not in use, to an on mode, in which the source of energy 36 supplies energy for the operation of the restriction device 4.

FIGURE 14 shows an embodiment of the invention identical to

that of FIGURE 13, except that an energy storage device 240 also is implanted in the patient for storing the storable energy transformed from the wireless energy by the transforming device of the control unit 6. In this case, the implanted control unit 6 controls the energy storage device 240 to operate the switch 238 to switch between an off mode, in which the implanted source of energy 236 is not in use, and an on mode, in which the implanted source of energy 236 supplies energy for the operation of the restriction device 4.

FIGURE 15 shows an embodiment of the invention identical to that of FIGURE 13, except that a motor 242 and a mechanical reversing device in the form of a gearbox 244 also are implanted in the patient. The implanted control unit 6 controls the gearbox 244 to reverse the function performed by the restriction device 4 (mechanically operated), i.e. enlarging and restricting the food passageway.

FIGURE 16 schematically shows conceivable combinations of implanted components of the apparatus for achieving various communication possibilities. Basically, there are the implanted restriction device 4, the implanted control unit 6 and the external control unit 10 including the external source of energy and the wireless remote control. As already described above the remote control transmits a control signal generated by the external source of energy, and the control signal is received by a signal receiver incorporated in the implanted control unit 6, whereby the control unit 6 controls the implanted restriction device 4 in response to the control signal.

A sensor 54 may be implanted in the patient for sensing a physical parameter of the patient, such as the pressure in the food passageway. The control unit 6, or alternatively the external control unit 10, may control the restriction device 4 in response to signals from the sensor 54. A transceiver may be

combined with the sensor 54 for sending information on the sensed physical parameter to the external control unit 10. The wireless remote control of the external control unit 10 may comprise a signal transmitter or transceiver and the implanted control unit 6 may comprise a signal receiver or transceiver. Alternatively, the wireless remote control of the external control unit 10 may comprise a signal receiver or transceiver and the implanted control unit 6 may comprise a signal transmitter or transceiver. The above transceivers, transmitters and receivers may be used for sending information or data related to the restriction device from inside the patient's body to the outside thereof.

The motor 44 may be implanted for operating the restriction device 4 and also the battery 32 may be implanted for powering the motor 44. The battery 32 may be equipped with a transceiver for sending information on the charge condition of the battery.

Those skilled in the art will realize that the above various embodiments according to FIGURES 1-15 could be combined in many different ways. For example, the energy operated switch 14 could be incorporated in any of the embodiments of FIGURES 4, 6, 8-10. The hydraulic shifting device 38 could be incorporated in any of the embodiments of FIGURES 4 and 9. The gearbox 52 could be incorporated in any of the embodiments of FIGURES 1, 6 and 8.

FIGURE 17 illustrates how any of the above-described embodiments of the heartburn and reflux disease treatment apparatus of the invention may be implanted in a patient. Thus, an assembly of the apparatus implanted in the patient comprises a restriction device 56 engaging the esophagus 58 close to the cardia, and an operation device 60 for operating the restriction device 56 and an internal control unit 62, which includes a signal receiver, for controlling the operation device 60. An external control unit 64 includes a signal transmitter for transmitting a control signal to the signal receiver of the

implanted control unit 62. The implanted control unit 62 is capable of transforming signal energy from the control signal into electric energy for powering the operation device 60 and for energizing energy consuming implanted components of the apparatus.

FIGURE 18 shows the basic parts of a wireless remote control of the apparatus of the invention including an electric motor 128 for operating a restriction member, for example of the type illustrated in FIGURE 17. In this case, the remote control is based on the transmission of electromagnetic wave signals, often of high frequencies in the order of 100 kHz - 1 gHz, through the skin 130 of the patient. In FIGURE 18, all parts placed to the left of the skin 130 are located outside the patient's body and all parts placed to the right of the skin 130 are implanted. Any suitable remote control system may be used.

An external signal transmitting antenna 132 is to be positioned close to a signal receiving antenna 134 implanted close to the skin 130. As an alternative, the receiving antenna 134 may be placed for example inside the abdomen of the patient. The receiving antenna 134 comprises a coil, approximately 1-100 mm, preferably 25 mm in diameter, wound with a very thin wire and tuned with a capacitor to a specific high frequency. A small coil is chosen if it is to be implanted under the skin of the patient and a large coil is chosen if it is to be implanted in the abdomen of the patient. The transmitting antenna 132 comprises a coil having about the same size as the coil of the receiving antenna 134 but wound with a thick wire that can handle the larger currents that is necessary. The coil of the transmitting antenna 132 is tuned to the same specific high frequency as the coil of the receiving antenna 134.

An external control unit 136 comprises a microprocessor, a high frequency electromagnetic wave signal generator and a power

amplifier. The microprocessor of the control unit 136 is adapted to switch the generator on/off and to modulate signals generated by the generator to send digital information via the power amplifier and the antennas 132,134 to an implanted control unit 138. To avoid that accidental random high frequency fields trigger control commands, digital signal codes are used. A conventional keypad placed on the external control unit 136 is connected to the microprocessor thereof. The keypad is used to order the microprocessor to send digital signals to either contract or enlarge the restriction device. The microprocessor starts a command by applying a high frequency signal on the antenna 132. After a short time, when the signal has energized the implanted parts of the control system, commands are sent to contract or enlarge the restriction device in predefined steps. The commands are sent as digital packets in the form illustrated below.

Start pattern, 8 bits	Command, 8 bits	Count, 8 bits	Checksum, 8 bits
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The commands are sent continuously during a rather long time period (e.g. about 30 seconds or more). When a new contract or enlarge step is desired the Count byte is increased by one to allow the implanted control unit 138 to decode and understand that another step is demanded by the external control unit 136. If any part of the digital packet is erroneous, its content is simply ignored.

Through a line 140, an implanted energizer unit 126 draws energy from the high frequency electromagnetic wave signals received by the receiving antenna 134. The energizer unit 126 stores the energy in a power supply, such as a large capacitor,

powers the control unit 138 and powers the electric motor 128 via a line 142.

The control unit 138 comprises a demodulator and a microprocessor. The demodulator demodulates digital signals sent 5 from the external control unit 136. The microprocessor of the control unit 138 receives the digital packet, decodes it and, provided that the power supply of the energizer unit 126 has sufficient energy stored, sends a signal via a signal line 144 to the motor 128 to either contract or enlarge the restriction 10 device depending on the received command code.

Alternatively, the energy stored in the power supply of the energizer unit may only be used for powering a switch, and the energy for powering the motor 128 may be obtained from another implanted power source of relatively high capacity, for example 15 a battery. In this case the switch is adapted to connect said battery to the control unit 138 in an on mode when said switch is powered by said power supply and to keep said battery disconnected from the control unit in a standby mode when said switch is unpowered.

20 With reference to FIGURE 19, the remote control schematically described above will now be described in accordance with a more detailed embodiment. The external control unit 136 comprises a microprocessor 146, a signal generator 148 and a power amplifier 150 connected thereto. The microprocessor 146 is 25 adapted to switch the signal generator 148 on/off and to modulate signals generated by the signal generator 148 with digital commands that are sent to implanted components of the apparatus. The power amplifier 150 amplifies the signals and sends them to the external signal transmitting antenna 132. The 30 antenna 132 is connected in parallel with a capacitor 152 to form a resonant circuit tuned to the frequency generated by the signal generator 148.

The implanted signal receiving antenna coil 134 forms together with a capacitor 154 a resonant circuit that is tuned to the same frequency as the transmitting antenna 132. The signal receiving antenna coil 134 induces a current from the received 5 high frequency electromagnetic waves and a rectifying diode 160 rectifies the induced current, which charges a storage capacitor 158. A coil 156 connected between the antenna coil 134 and the diode 160 prevents the capacitor 158 and the diode 160 from loading the circuit of the signal receiving antenna 134 at higher 10 frequencies. Thus, the coil 156 makes it possible to charge the capacitor 158 and to transmit digital information using amplitude modulation.

A capacitor 162 and a resistor 164 connected in parallel and a diode 166 forms a detector used to detect amplitude modulated 15 digital information. A filter circuit is formed by a resistor 168 connected in series with a resistor 170 connected in series with a capacitor 172 connected in series with the resistor 168 via ground, and a capacitor 174, one terminal of which is connected between the resistors 168,170 and the other terminal of which is connected between the diode 166 and the circuit formed by the capacitor 162 and resistor 164. The filter circuit is used to filter out undesired low and high frequencies. The detected and filtered signals are fed to an implanted microprocessor 176 that decodes the digital information and controls the motor 128 via 20 an H-bridge 178 comprising transistors 180,182,184 and 186. The motor 128 can be driven in two opposite directions by the H-bridge 178.

The microprocessor 176 also monitors the amount of stored 25 energy in the storage capacitor 158. Before sending signals to activate the motor 128, the microprocessor 176 checks whether the energy stored in the storage capacitor 158 is enough. If the stored energy is not enough to perform the requested operation,

the microprocessor 176 waits for the received signals to charge the storage capacitor 158 before activating the motor 128.

CLAIMS.

1. A heartburn and reflux disease treatment apparatus,  
5 comprising a restriction device implantable in a patient, who  
suffers from heartburn and reflux disease, for engaging the  
stomach close to the cardia or engaging the esophagus, to form  
a restricted food passageway in the stomach or esophagus,  
characterised in that the restriction device is operable to  
10 change the restriction of the restricted food passageway, a  
source of energy is provided, and a control device operable from  
outside the patient's body is provided for controlling the source  
of energy to release energy for use in connection with the  
operation of the restriction device, when the restriction device  
15 is implanted.

2. An apparatus according to claim 1, wherein the source of  
energy is intended to be external to the patient's body when the  
restriction device is implanted therein, and the control device  
20 is adapted to control the external source of energy to release  
wireless energy for use in connection with the operation of the  
restriction device.

3. An apparatus according to claim 1 or 2, wherein the  
25 control device controls the restriction device.

4. An apparatus according to claim 3, wherein the control  
device comprises an internal control unit implantable in the  
patient for controlling the restriction device.

30

5. An apparatus according to claim 4, wherein the internal  
control unit is programmable.

6. An apparatus according to claim 5, wherein the control device comprises an external control unit intended to be outside the patient's body, the internal control unit being programmable 5 by the external control unit.

7. An apparatus according to claim 5, wherein the internal control unit is programmable for controlling the restriction device over time.

10

8. An apparatus according to claim 7, wherein the internal control unit controls the restriction device over time in accordance with an activity schedule program.

15

9. An apparatus according to claim 7, wherein the internal control unit comprises a microprocessor.

20

10. An apparatus according to claim 6, wherein the external control unit loads the internal control unit with data in accordance with a loading mode only authorized for a doctor.

25

11. An apparatus according to claim 6, wherein the external control unit controls the internal control unit in accordance with a doctor mode only authorized for a doctor.

30

12. An apparatus according to claim 6, wherein the external control unit controls the internal control unit in accordance with a patient mode permitted for the patient.

35

13. An apparatus according to claim 1, wherein the source of energy is implantable in the patient.

14. An apparatus according to claim 13, wherein the implantable source of energy comprises at least one accumulator, at least one capacitor or at least one rechargeable battery, or a combination of at least one capacitor and at least one rechargeable battery.

15. An apparatus according to claim 14, wherein the implantable source of energy comprises an electric source of energy.

10

16. An apparatus according to claim 15, wherein the electric source of energy comprises an accumulator, or a battery having a lifetime of at least 10 years.

15

17. An apparatus according to any of claims 1-16, wherein the control device controls the restriction device.

20

18. An apparatus according to claim 2, further comprising an energy storage device implantable in the patient for storing the wireless energy released from the external source of energy.

19. An apparatus according to claim 18, wherein the energy storage device comprises an accumulator.

25

20. An apparatus according to claim 19, wherein the accumulator comprises an electric accumulator.

30

21. An apparatus according to claim 20, wherein the electric accumulator comprises at least one capacitor or at least one rechargeable battery, or a combination of at least one capacitor and at least one rechargeable battery.

22. An apparatus according to claim 1 or 2, further comprising a battery implantable in the patient for supplying electric energy to implantable electric energy consuming components of the apparatus.

5

23. The apparatus according to claim 2, wherein the control device is adapted to control the external source of energy to release wireless energy for direct use in connection with the operation of the restriction device.

10

24. The apparatus according to claim 23, wherein the control device is adapted to control the external source of energy to intermittently release wireless energy in the form of a train of energy pulses for direct use in connection with the operation of 15 the restriction device.

20

25. The apparatus according to claim 23 or 24, wherein the restriction device is operable in a non-magnetic, non-thermal or non-mechanical manner by use of said released wireless energy.

25

26. The apparatus according to any of claims 1,2 and 17, further comprising a switch implantable in the patient for directly or indirectly switching the operation of the restriction device.

30

27. The apparatus according to claim 26, further comprising an internal source of energy implantable in the patient for supplying energy for the operation of the restriction device, wherein the switch directly or indirectly affects the supply of energy from the internal source of energy.

28. The apparatus according to claim 27, wherein the switch

switches between an "off" mode, in which the internal source of energy is not in use, and an "on" mode, in which the internal source of energy supplies energy for the operation of the restriction device.

5

29. The apparatus according to claim 2 and 28, wherein the switch is operable by the wireless energy released from the external source of energy.

10

30. The apparatus according to claim 29, wherein the control device controls the external source of energy to release the wireless energy.

15

31. The apparatus according to any of claims 1,2 and 30, wherein the control device comprises a wireless remote control.

32. The apparatus according to claim 27, wherein the control device comprises a wireless remote control for controlling the internal source of energy.

20

33. The apparatus according to claim 32, wherein the switch is operable by the wireless energy from the external source of energy to switch between an "off" mode, in which the internal source of energy and remote control are not in use, and a "standby" mode, in which the remote control is permitted to control the internal source of energy to supply energy for the operation of the restriction device.

30

34. The apparatus according to claim 27, further comprising an energy transforming device implantable in the patient for transforming the wireless energy into storable energy and an energy storage device implantable in the patient for storing the

storables energy.

35. The apparatus according to claim 34, wherein the switch is operable by energy from the implantable energy storage device 5 to switch between an "off" mode, in which the internal source of energy is not in use, and an "on" mode, in which the internal source of energy supplies energy for the operation of the restriction device.

10 36. The apparatus according to claim 35, wherein the control device controls the energy storage device to operate the switch.

37. The apparatus according to claim 17 or 36, wherein the control device comprises a wireless remote control.

15 38. The apparatus according to claim 27, further comprising an energy transforming device implantable in the patient for transforming the wireless energy into storables energy, wherein the internal source of energy is capable of storing the storables 20 energy.

39. The apparatus according to claim 38, wherein the switch switches from an "off" mode, in which the internal source of energy is not in use, to an "on" mode, in which the source of 25 energy supplies energy for the operation of the restriction device.

40. The apparatus according to claim 39, wherein the control device controls the switch to switch between the "on" and "off" 30 modes.

41. The apparatus according to claim 40, wherein the control

device comprises a wireless remote control.

42. The apparatus according to claim 27, wherein the internal source of energy comprises an electric source of energy.

5

43. The apparatus according to claim 42, wherein the electric source of energy comprises at least one accumulator, at least one capacitor or at least one rechargeable battery, or a combination of at least one capacitor and at least one 10 rechargeable battery.

44. The apparatus according to claim 42, wherein the electric source of energy comprises an accumulator or a battery having a lifetime of at least 10 years.

15

45. The apparatus according to claim 1, wherein the source of energy comprises a nuclear source of energy.

46. The apparatus according to claim 1, wherein the source 20 of energy comprises a chemical source of energy.

47. An apparatus according to any one of claims 1, 2, 13 or 26, further comprising an operation device implantable in the patient for operating the restriction device.

25

48. An apparatus according to claim 2 or 23, further comprising an operation device implantable in the patient for operating the restriction device, wherein the wireless energy directly or indirectly powers the operation device.

30

49. An apparatus according to claim 47 or 48, wherein the control device controls the operation device to operate the

restriction device.

50. An apparatus according to claim 49, wherein the operation device comprises hydraulic means and at least one valve 5 for controlling a fluid flow in the hydraulic means.

51. An apparatus according to claim 50, wherein the control device comprises a wireless remote control for controlling the valve.

10

52. An apparatus according to claim 49, wherein the restriction device comprises hydraulic means and the operation device comprises a reservoir forming a fluid chamber with a variable volume connected to the hydraulic means, and the 15 operation device is adapted to distribute fluid from the chamber to the hydraulic means by reduction of the volume of the chamber and to withdraw fluid from the hydraulic means to the chamber by expansion of the volume of the chamber.

20

53. An apparatus according to claim 47 or 49, wherein the operation device comprises a motor.

54. An apparatus according to claim 53, wherein the motor comprises a rotary motor, and the control device controls the 25 rotary motor to rotate a desired number of revolutions.

55. An apparatus according to claim 53, wherein the motor comprises a linear motor.

30

56. An apparatus according to claim 53, wherein the motor comprises a hydraulic or pneumatic fluid motor, and the control device controls the fluid motor.

57. An apparatus according to claim 53, wherein the motor comprises an electric motor having electrically conductive parts made of plastics.

5

58. An apparatus according to any one of claims 1,47-49, wherein the control device releases polarized energy from the source of energy.

10

59. An apparatus according to any one of claims 47-49, wherein the control device shifts polarity of the released energy to reverse the operation device.

15

60. An apparatus according to any one of claims 47-49, wherein the operation device comprises an electric motor and the released energy comprises electric energy.

20

61. An apparatus according to any one of claims 1,13,47-49 and 53, wherein the restriction device is operable to perform a reversible function.

25

62. An apparatus according to claim 61, further comprising a reversing device implantable in the patient for reversing the function performed by the restriction device.

63. An apparatus according to claim 62, wherein the control device controls the reversing device to reverse the function performed by the restriction device.

30

64. An apparatus according to claim 62, wherein the reversing device comprises hydraulic means including a valve for shifting the flow direction of a fluid in the hydraulic means.

65. An apparatus according to claim 62, wherein the reversing device comprises a mechanical reversing device.

5 66. An apparatus according to claim 65, wherein the mechanical reversing device comprises a switch.

67. An apparatus according to claim 65, wherein the reversing device comprises a gearbox.

10

68. An apparatus according to claim 62, wherein the reversing device comprises a switch.

15 69. An apparatus according to claim 68, wherein the switch of the reversing device is operable by the released energy.

20 70. An apparatus according to claim 69, wherein the control device controls the operation of the switch of the reversing device by shifting polarity of the released energy supplied to the switch.

71. An apparatus according to claim 68, wherein the switch comprises an electric switch and the source of energy supplies electric energy for the operation of the switch.

25

72. An apparatus according to claim 68, wherein the operation device comprises a motor, and the reversing device reverses the motor.

30

73. An apparatus according to any of claims 1,2,13,47-49, wherein the restriction device comprises hydraulic means and the operation device is adapted to conduct a hydraulic fluid in the

hydraulic means.

74. An apparatus according to claim 73, wherein the operation device comprises a motor.

5

75. An apparatus according to claim 73 or 74, wherein the operation device comprises a fluid conduit connected to the hydraulic means of the restriction device, and a reservoir for fluid, the reservoir forming part of the conduit.

10

76. An apparatus according to claim 75, wherein the hydraulic means and conduit are devoid of any non-return valve.

15

77. An apparatus according to claim 76, wherein the reservoir forms a fluid chamber with a variable volume, and the operation device is adapted to distribute fluid from the chamber to the hydraulic means of the restriction device by reduction of the volume of the chamber and to withdraw fluid from the hydraulic means to the chamber by expansion of the volume of the chamber.

20

78. An apparatus according to any of the preceding claims, further comprising at least one implantable sensor for sensing at least one physical parameter of the patient.

25

79. An apparatus according to claim 78, wherein the sensor comprises a pressure sensor for directly or indirectly sensing as the physical parameter the pressure in the food passageway.

30

80. An apparatus according to claim 78 or 79, wherein the control device controls the restriction device in response to signals from the sensor.

81. An apparatus according to claim 80, wherein the control device comprises an internal control unit implantable in the patient, the internal control unit controlling the restriction device in response to signals from the sensor.

82. An apparatus according to claim 81, wherein the control device comprises an external control unit outside the patient's body, the external control unit controlling the restriction device in response to signals from the sensor.

83. An apparatus according to claim 82, wherein the external control unit stores information on the physical parameter sensed by the sensor and is manually operated to control the restriction device based on the stored information.

84. An apparatus according to any of claims 78-83, further comprising at least one implantable sender for sending information on the physical parameter sensed by the sensor.

20

85. An apparatus according to any of the preceding claims, further comprising an external data communicator intended to be outside the patient's body and an internal data communicator implantable in the patient for communicating with the external communicator, wherein the internal data communicator feeds data related to the patient back to the external data communicator or the external data communicator feeds data to the internal data communicator.

30 86. An apparatus according to claim 85, wherein the internal data communicator feeds data related to the restriction device.

87. An apparatus according to claim 85 or 86, wherein the implantable communicator feeds data related to at least one physical signal of the patient.

5 88. An apparatus according to any of the preceding claims, wherein the restriction device is adapted to control the cross-sectional area of the food passageway.

10 89. An apparatus according to claim 88, wherein the restriction device is operable to open and close the food passageway when implanted in the patient.

15 90. An apparatus according to claim 88 or 89, wherein the restriction device is adapted to steplessly control the cross-sectional area of the food passageway when implanted in the patient.

20 91. An apparatus according to any of the preceding claims, further comprising an implantable energy transforming device, wherein the control device is adapted to control the source of energy to release wireless electric energy and the energy transforming device is adapted to transform the electric energy into kinetic energy for operation of the restriction device.

25 92. An apparatus according to claim 91, wherein the restriction device is directly operated with the kinetic energy, as the energy transforming device transforms the electric energy into the kinetic energy.

30 93. An apparatus according to any of the preceding claims, wherein the control device controls the source of energy to release magnetic energy, non-magnetic energy, electromagnetic

energy, non-electromagnetic energy, kinetic energy, non-kinetic energy, sonic energy, non-sonic energy, thermal energy or non-thermal energy.

5 94. An apparatus according to any of the preceding claims, wherein the restriction device is non-inflatable.

10 95. An apparatus according to any of the preceding claims, wherein the control device controls the source of energy to release energy for a determined time period.

15 96. An apparatus according to any of claims 1-94, wherein the control device controls the source of energy to release energy in a determined number of energy pulses.

97. An apparatus according to any of the preceding claims, wherein the control device is adapted to control the source of energy to release energy in a non-invasive manner.

20 98. An apparatus according to any of the preceding claims, wherein the control device comprises a wireless remote control for transmitting at least one wireless control signal for controlling the restriction device.

25 99. An apparatus according to claim 98, wherein the remote control is capable of obtaining information on the condition of the restriction device when the restriction device is implanted and to control the restriction device in response to the information.

30

100. An apparatus according to claim 98 or 99, wherein the wireless remote control comprises at least one external signal

transmitter or transceiver and at least one internal signal receiver or transceiver implantable in the patient.

101. An apparatus according to claim 98 or 99, wherein the  
5 wireless remote control comprises at least one external signal receiver or transceiver and at least one internal signal transmitter or transceiver implantable in the patient.

102. An apparatus according to any of claims 98-101, wherein  
10 the remote control is capable of sending information related to the restriction device from inside the patient's body to the outside thereof.

103. An apparatus according to claim 102, wherein the remote  
15 control controls the restriction device in response to the information.

104. An apparatus according to any of claims 98-103, wherein  
the remote control transmits a carrier signal for carrying the  
20 control signal.

105. An apparatus according to claim 104, wherein the carrier signal is frequency, amplitude or frequency and amplitude modulated.

25

106. An apparatus according to claim 104 or 105, wherein the carrier signal is digital, analog or digital and analog.

107. An apparatus according to any of claims 104-106,  
30 wherein the control signal used with the carrier signal is frequency, amplitude or frequency and amplitude modulated.

108. An apparatus according to any of claims 98-107, wherein the control signal comprises a wave signal comprising one of a sound wave signal including an ultrasound wave signal, an electromagnetic wave signal including an infrared light signal, 5 a visible light signal, an ultra violet light signal and a laser light signal, a micro wave signal, a radio wave signal, an x-ray radiation signal, and a gamma radiation signal.

109. An apparatus according to claim 98-107, wherein the 10 control signal comprises an electric, magnetic or electric and magnetic field.

110. An apparatus according to any of claims 98-108, wherein the control signal is digital, analog or digital and analog.

15

111. An apparatus according to claim 110, wherein the remote control transmits an electromagnetic carrier wave signal for carrying the digital or analog control signal.

20

112. An apparatus according to any of claims 98-111, wherein the control signal is transmitted in pulses by the wireless remote control.

25

113. An apparatus according to any of claims 2,23-25,89-91, further comprising an implantable stabiliser for stabilising the energy released by the control device.

30

114. An apparatus according to claim 113, wherein the energy released by the control device comprises electric energy and the stabiliser comprises at least one capacitor.

115. An apparatus according to claim 1, wherein the

restriction device is operable by the released energy in a manual, mechanical, thermal or magnetic manner.

116. An apparatus according to claim 1, wherein the  
5 restriction device is operable by the released energy in a non-manual, non-mechanical, non-thermal or non-magnetic manner.

117. An apparatus according to claim 23 or 24, wherein the  
control device is adapted to control the source of energy to  
10 release electric energy, and further comprising an implantable  
capacitor for producing the train of energy pulses from the  
released energy.

118. An apparatus according to claim 1, further comprising  
15 an adjustment device for adjusting the restriction device to  
change the size of the stoma opening, wherein the adjustment  
device is adapted to mechanically adjust the restriction device,  
or adapted to hydraulically adjust the restriction device by  
using hydraulic means which is devoid of hydraulic fluid of the  
20 kind having a viscosity that substantially increases when exposed  
to heat or a magnetic field.

119. An apparatus according to claim 47, wherein the  
operation device comprises an electrical operation device.

25

120. An apparatus according to claim 47, wherein the  
operation device is powered by magnetic energy, non-magnetic  
energy, electromagnetic energy, non-electromagnetic energy,  
kinetic energy, non-kinetic energy, thermal energy or non-thermal  
30 energy.

121. An apparatus according to claim 1, wherein the control

device is activated in a manual or non-manual manner to control the source of energy to release energy.

122. An apparatus according to claim 1, further comprising 5 implantable electrical components including at least one voltage level guard.

123. An apparatus according to claim 1, further comprising 10 implantable electrical components including a single voltage level guard.

124. An apparatus according to claim 122 or 123, wherein the electrical components are devoid of any current detector and/or charge level detector.

15

125. An apparatus according to any of claims 121-124, further comprising an implantable capacitor or accumulator, wherein the charge or discharge of the capacitor or accumulator is controlled by use of the voltage level guard.

20

126. An apparatus according to claim 23, wherein the released energy comprises electric energy and further comprising an implantable capacitor for producing the train of energy pulses.

25

127. An apparatus according to claim 125 or 126, wherein the capacitor has a capacity less than 0,1  $\mu$ F.

128. An apparatus according to any of claims 1,2,23 and 24, 30 further comprising an implantable motor or pump for operating the restriction device, wherein the control device is adapted to control the source of energy to directly power the motor or pump

with the released energy.

129. An apparatus according to claim 23, wherein the wireless energy comprises electromagnetic waves excluding radio 5 waves.

130. An apparatus according to any of claims 2, 23 and 24, further comprising an implantable motor or pump for operating the restriction device, wherein the control device is adapted to 10 release wireless energy in the form of a magnetic field or electromagnetic waves for direct power of the motor or pump, as the wireless energy is being released.

131. An apparatus according to claim 130, wherein the pump 15 is not a plunger type of pump.

132. An apparatus according to any of claims 2, 23 or 24, wherein the wireless energy comprises a signal.

20 133. An apparatus according to claim 1, further comprising an implantable energy transforming device for transforming wireless energy directly or indirectly into energy different than the wireless energy for operation of the restriction device.

25 134. An apparatus according to claim 133, wherein the energy transforming device transforms the wireless energy in the form of sound waves into electric energy for operation of the restriction device.

30 135. An apparatus according to claim 134, wherein the energy transforming device transforms the wireless energy in the form of sound waves directly into electric energy.

136. An apparatus according to claim 134 or 135, wherein the energy transforming device comprises a capacitor.

5 137. An apparatus according to claim 136, wherein the capacitor is adapted to produce electric pulses from the transformed electric energy.

10 138. An apparatus according to any of claims 133-137, further comprising an implantable motor or pump for operating the restriction device, wherein the motor or pump is powered by the transformed energy.

15 139. An apparatus according to claim 1, wherein the restriction device is adjustable in a non-manual manner.

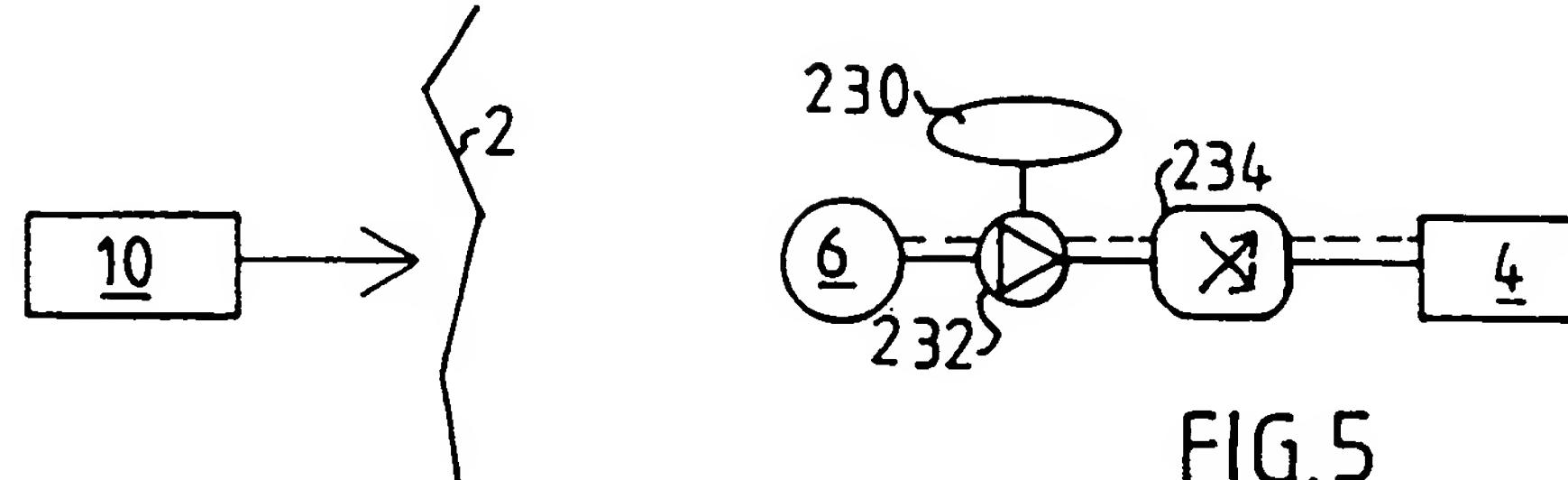
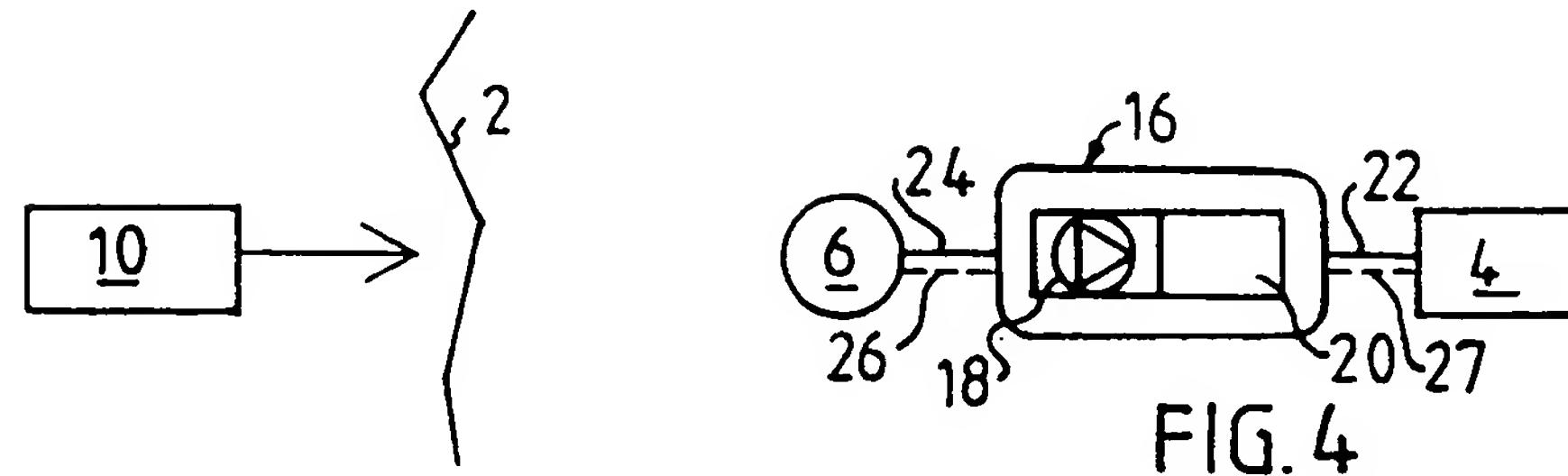
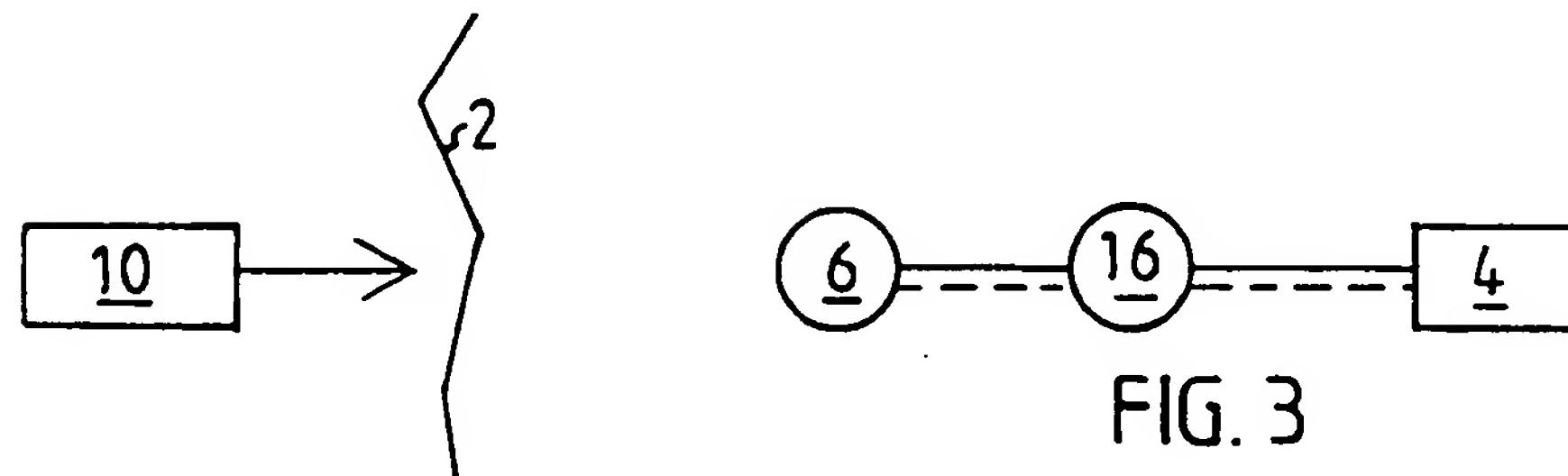
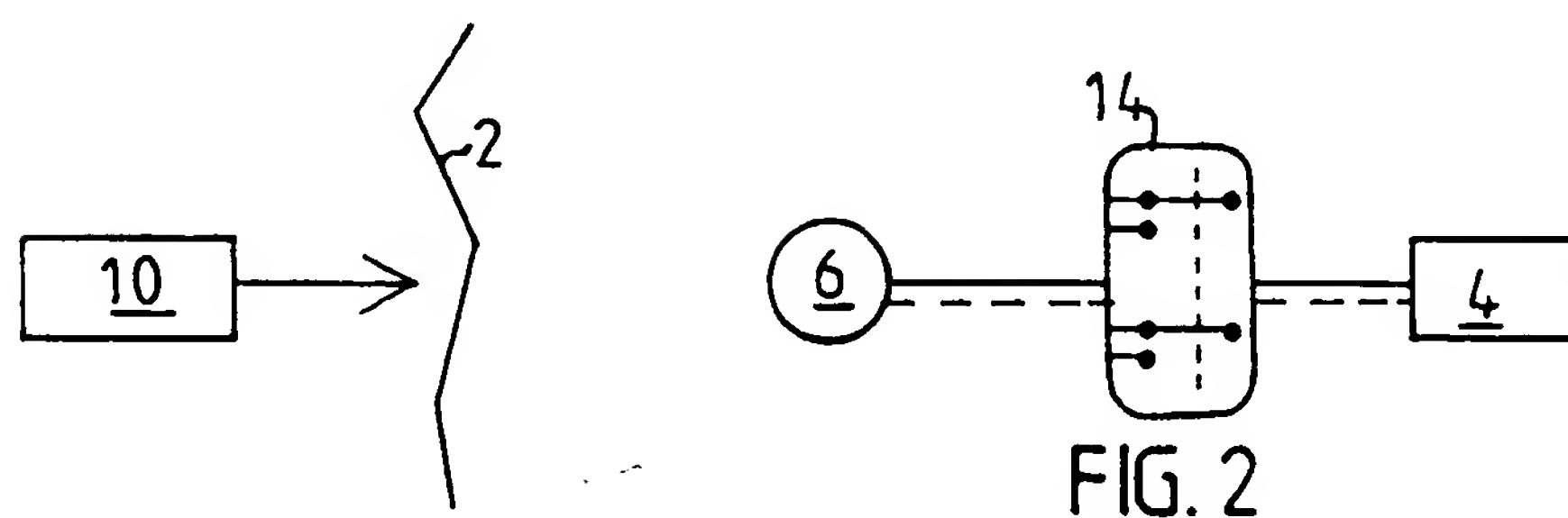
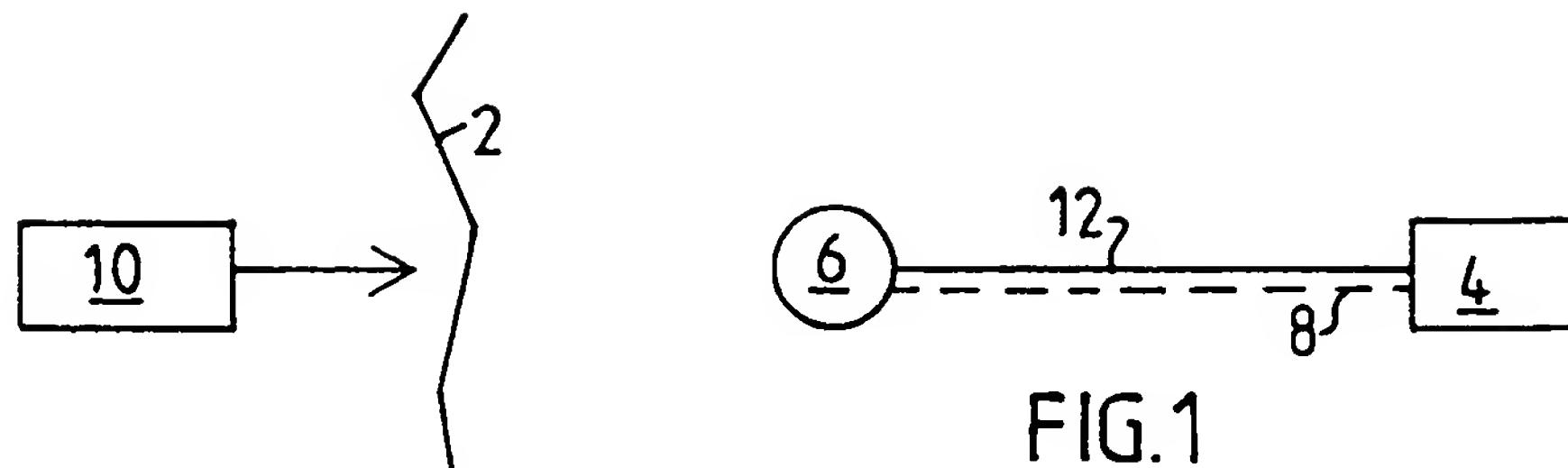
140. An apparatus according to any of the preceding claims, wherein the restriction device is embedded in a soft or gel-like material.

20

141. An apparatus according to any of the preceding claims, wherein the restriction device is embedded in a silicone material having hardness less than 20 Shore.

25

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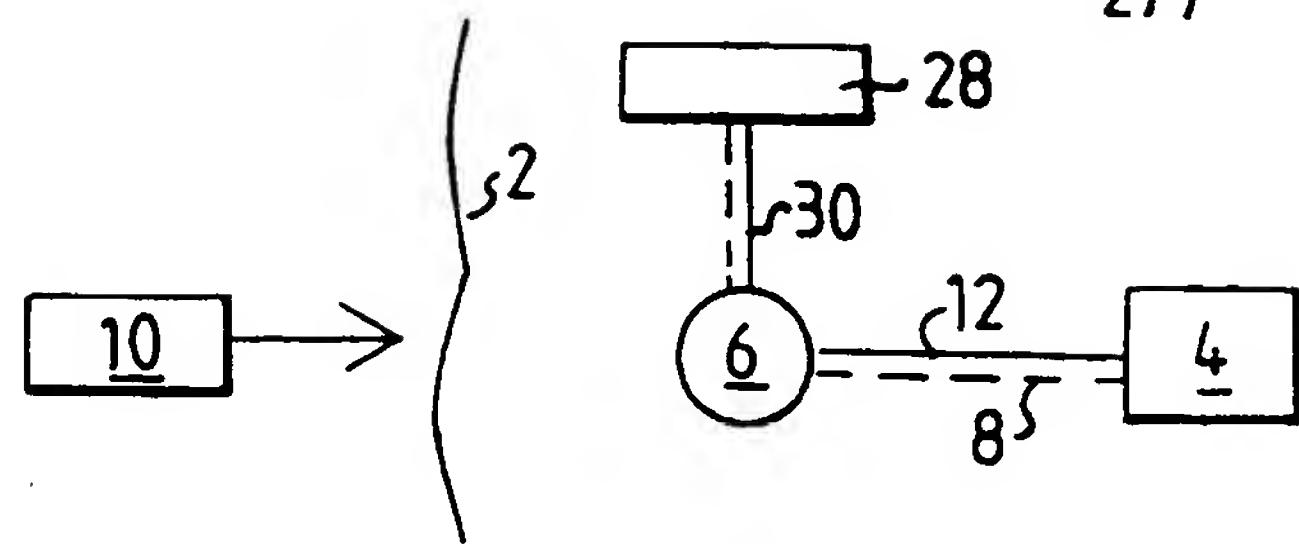


FIG. 6

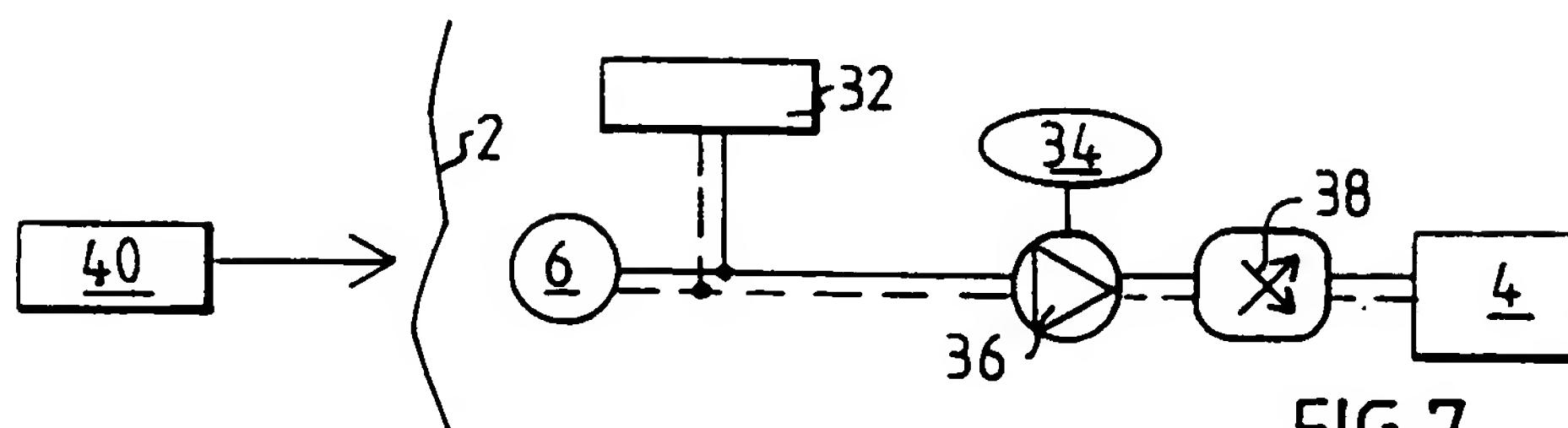


FIG. 7

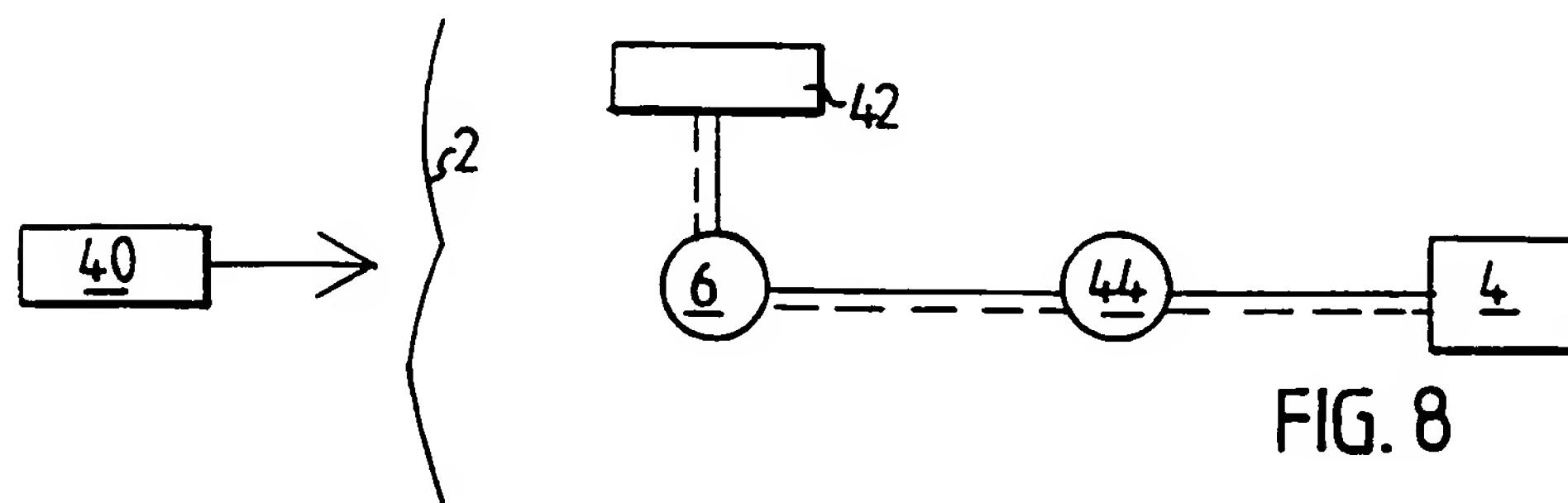


FIG. 8

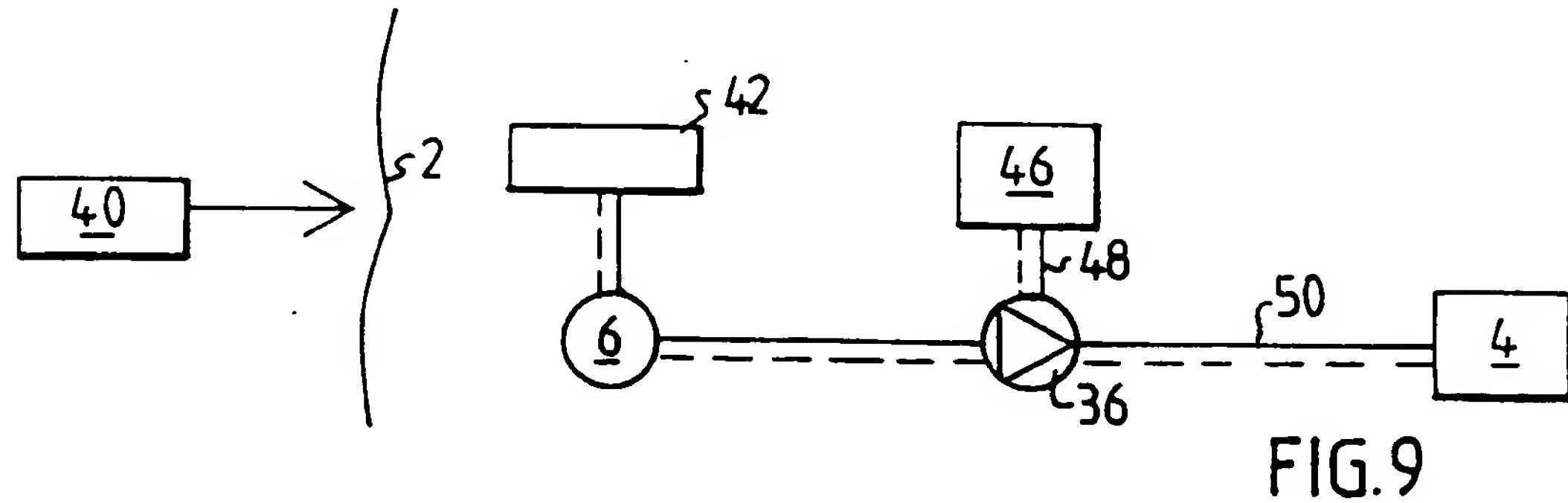


FIG. 9

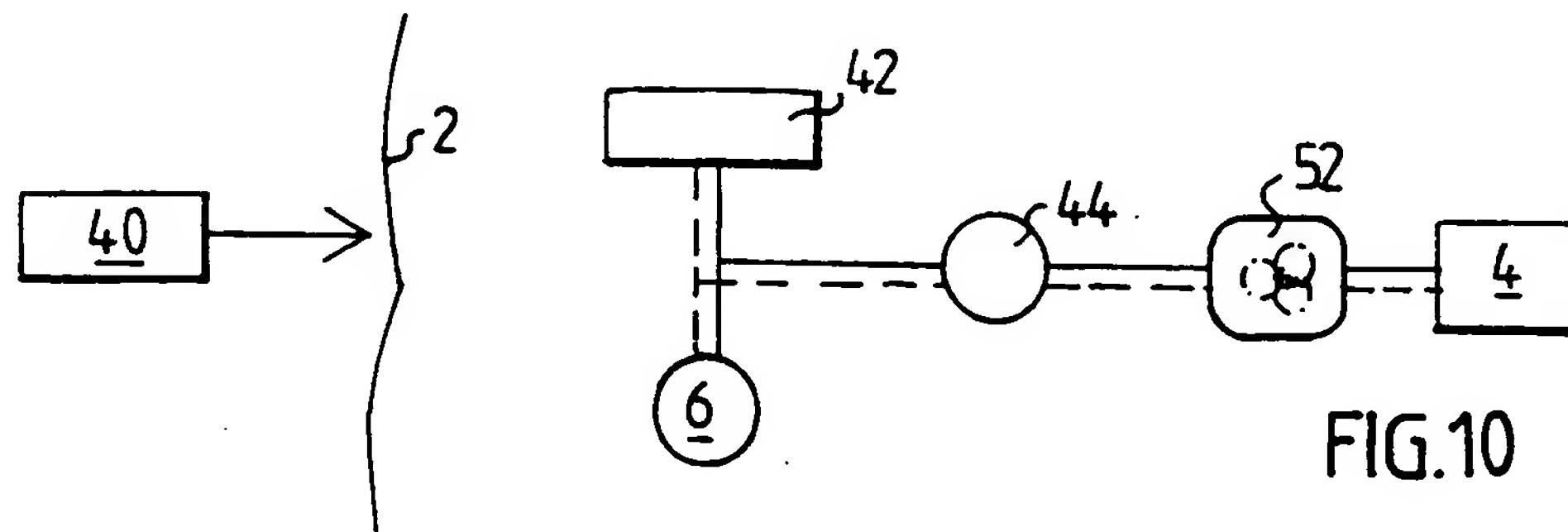
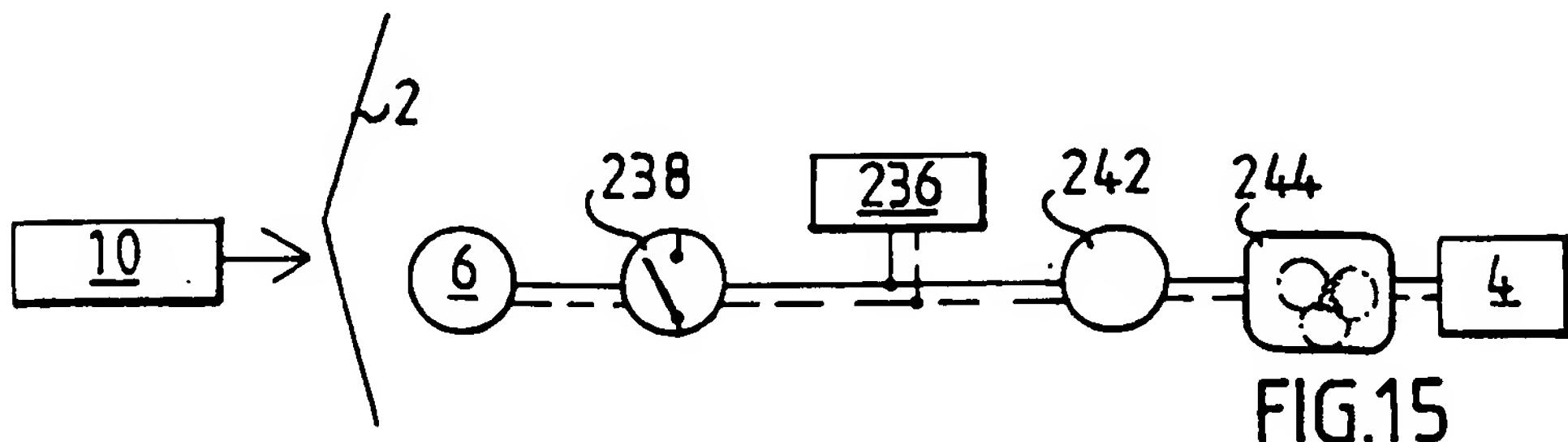
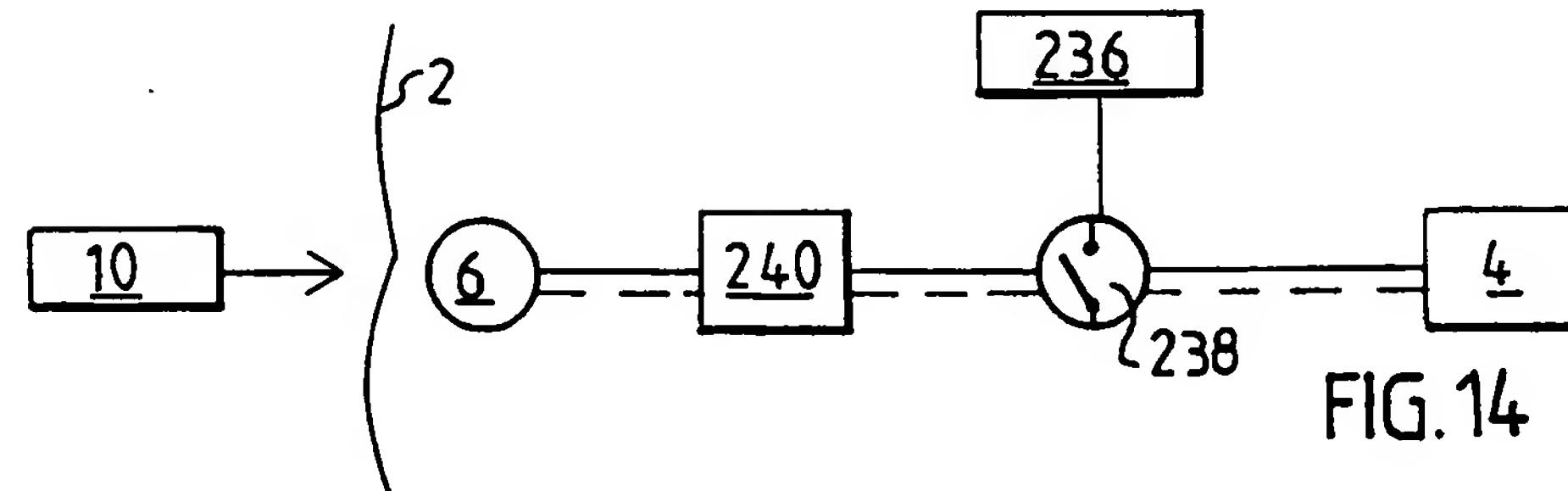
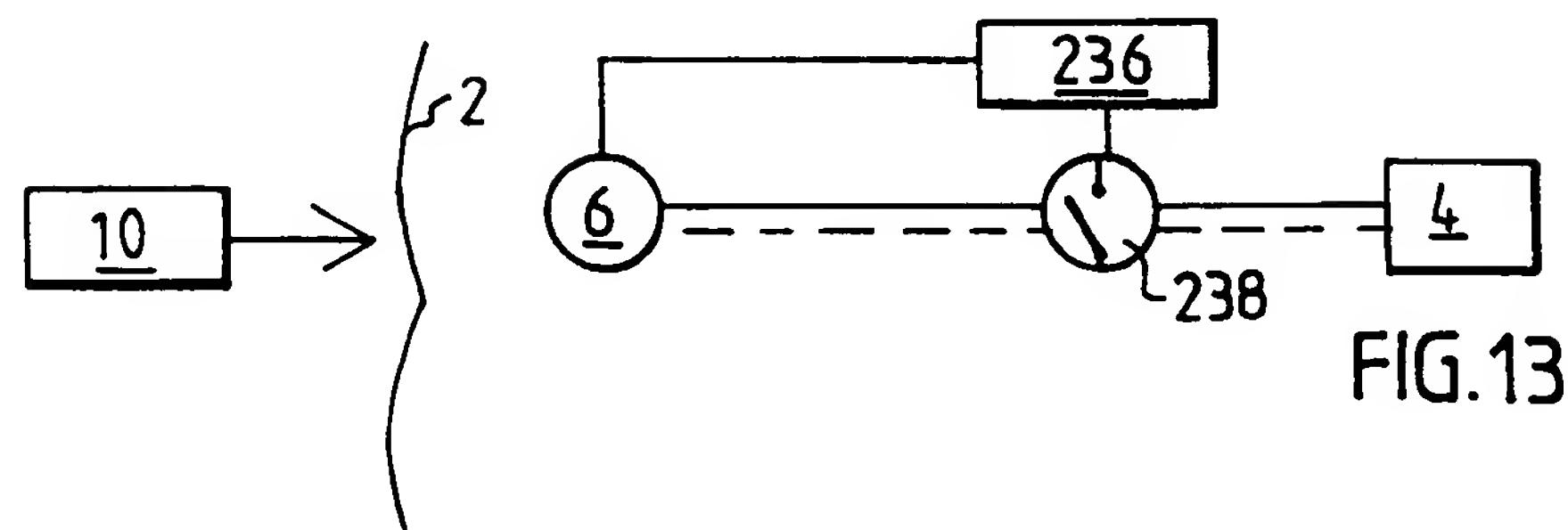
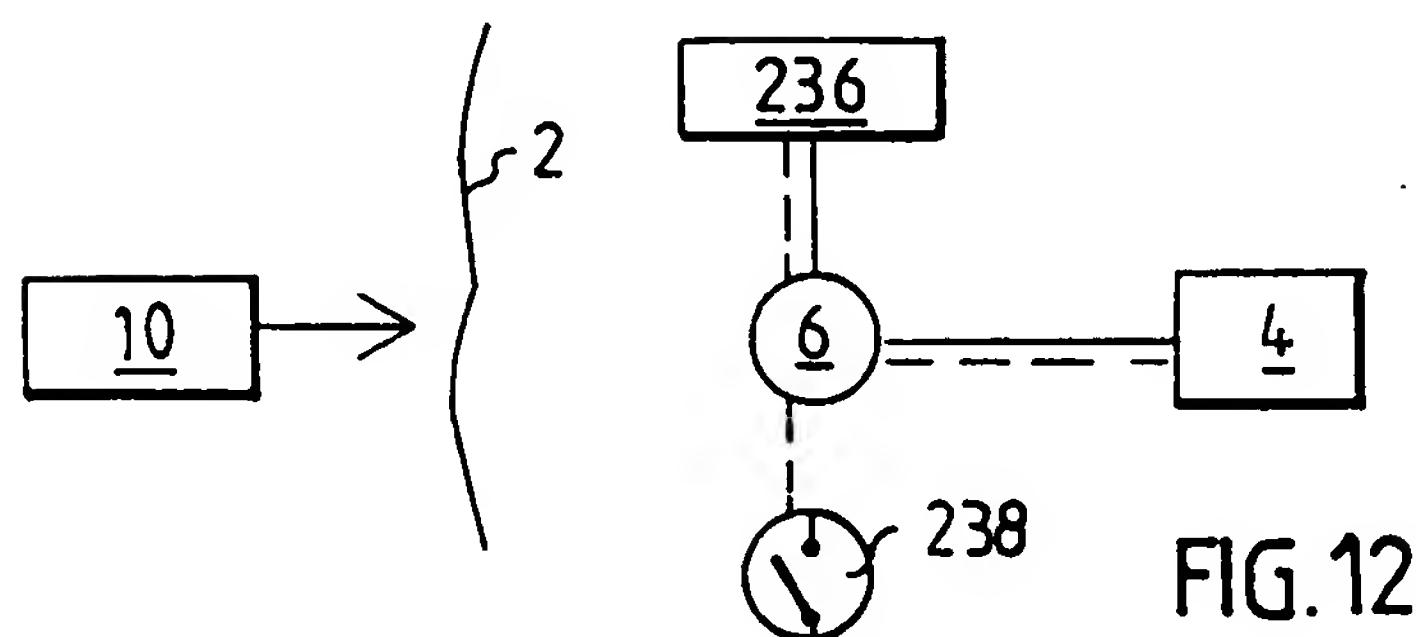
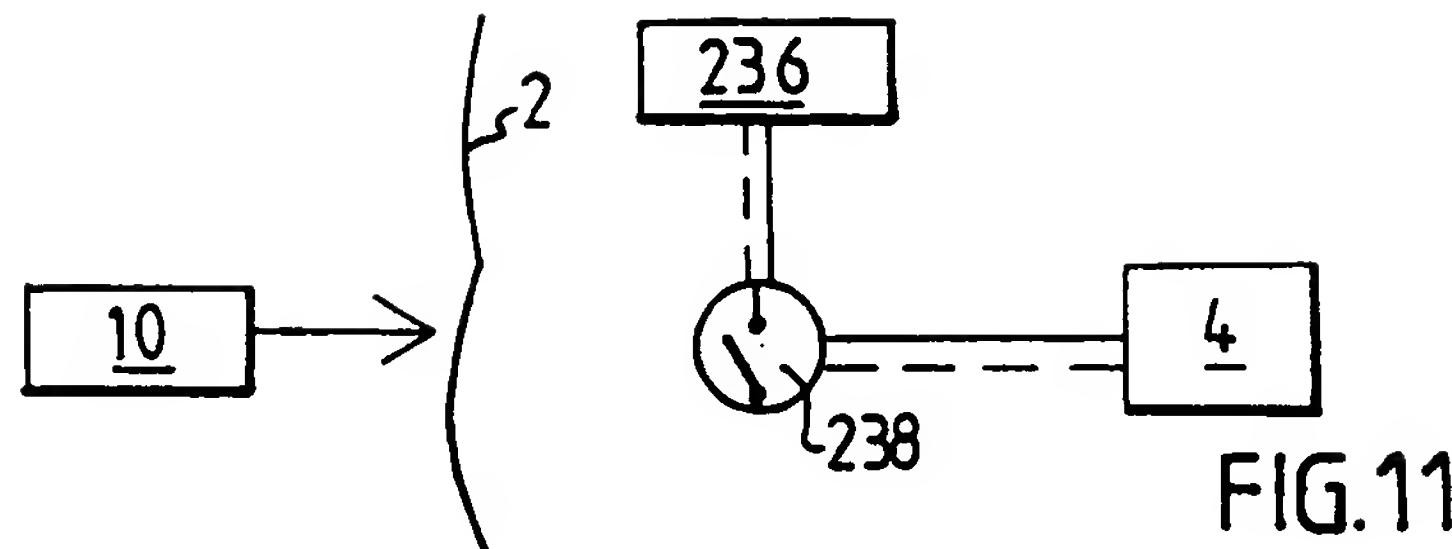


FIG. 10

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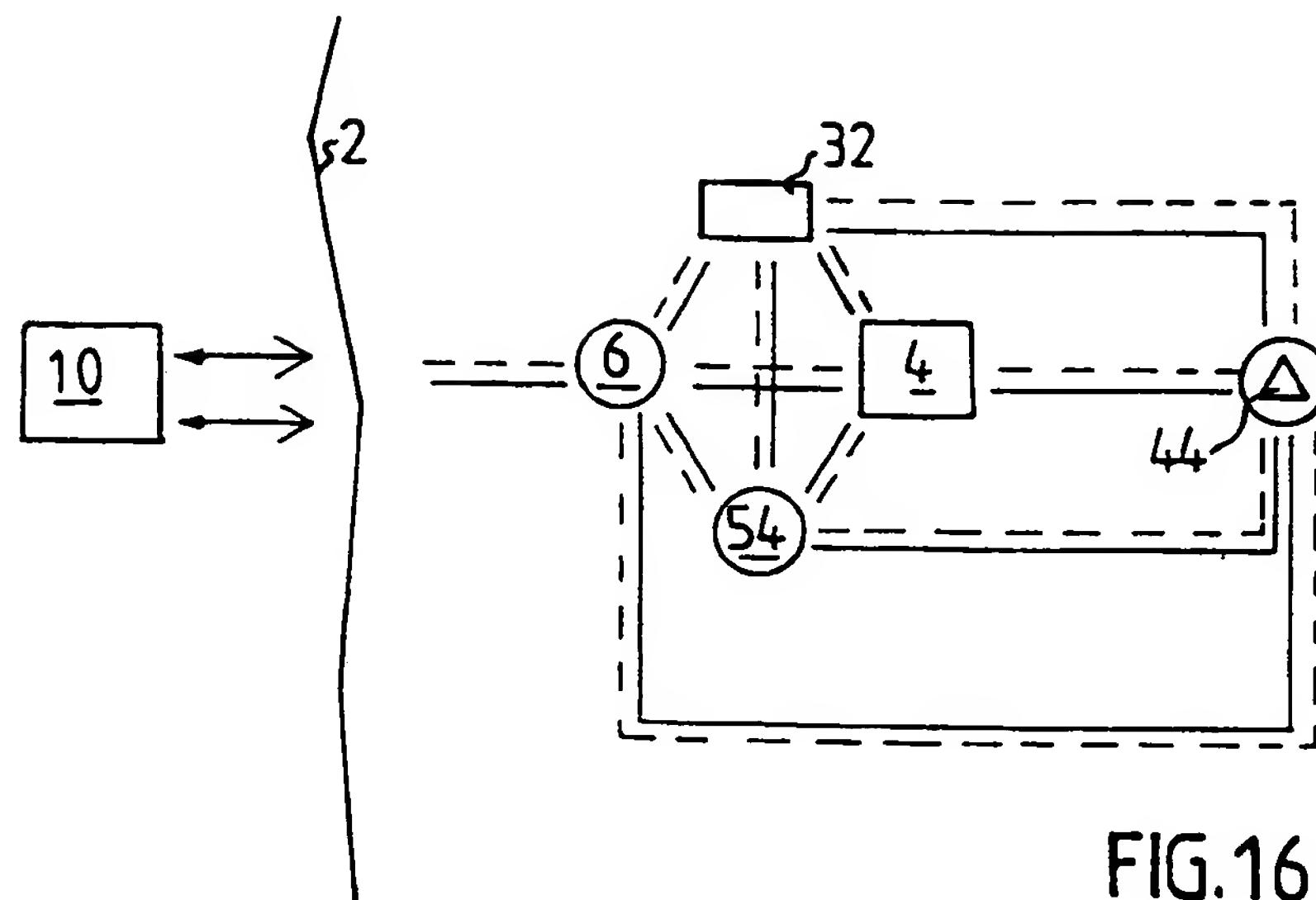
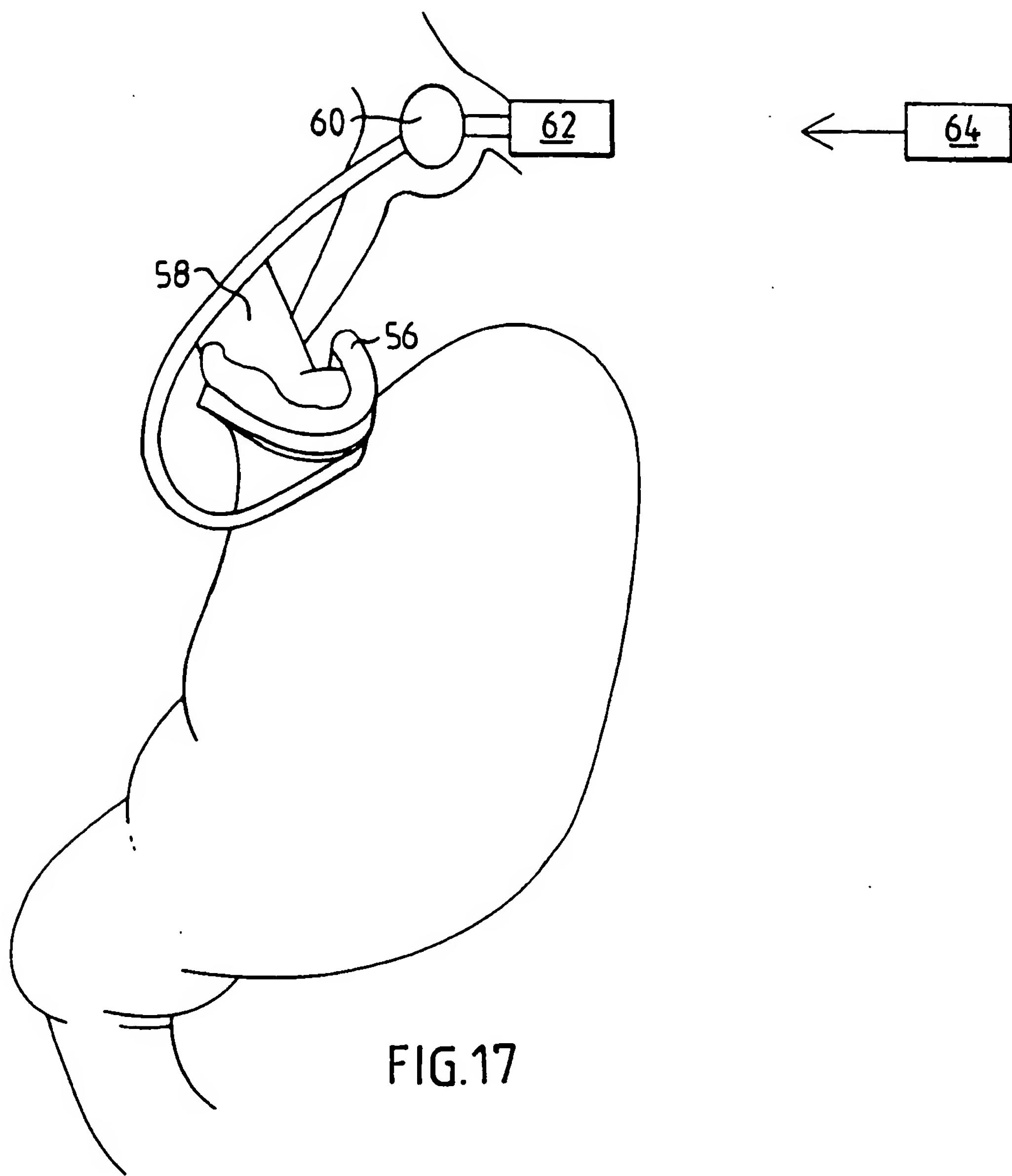


FIG.16

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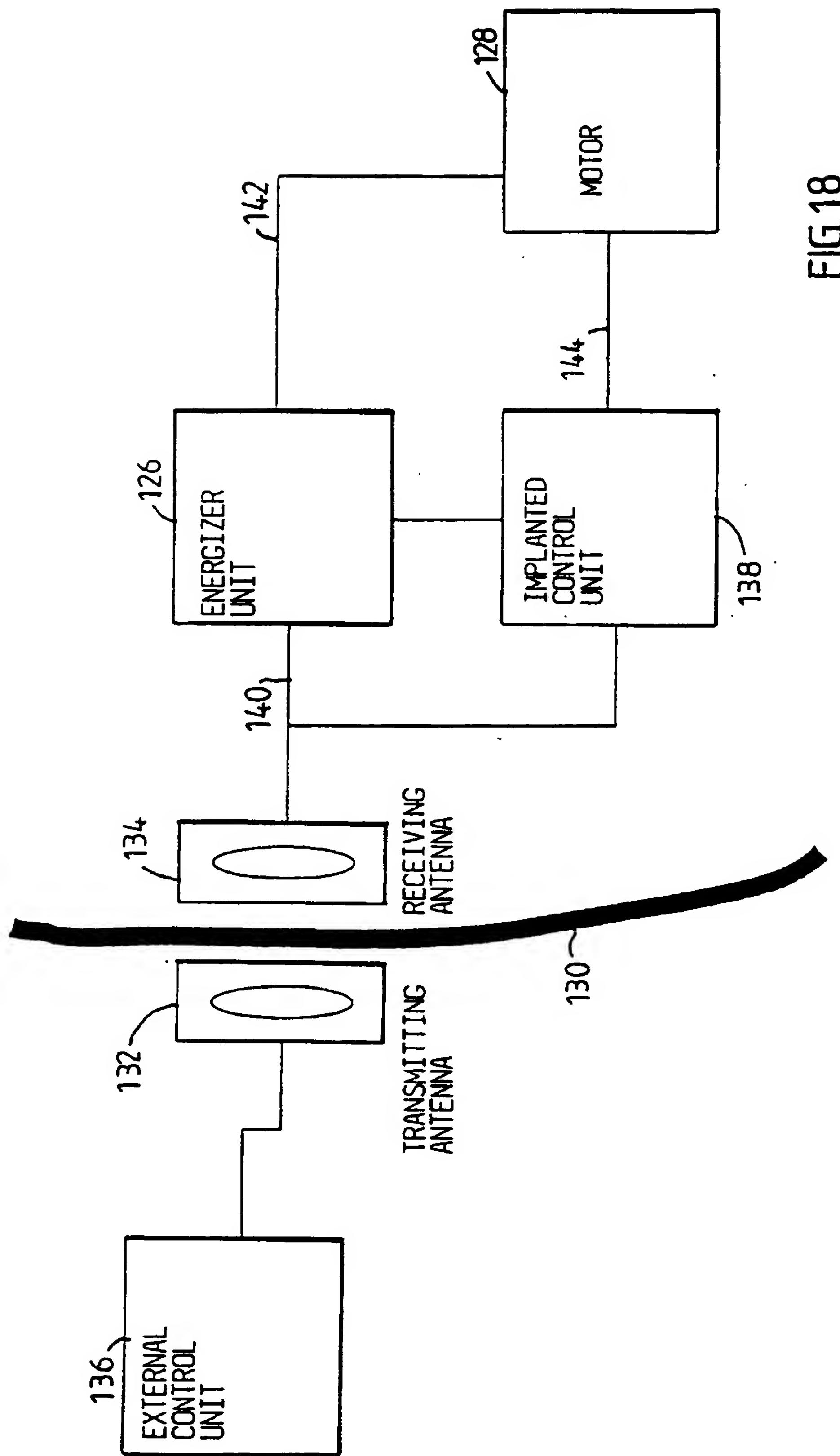


FIG.18

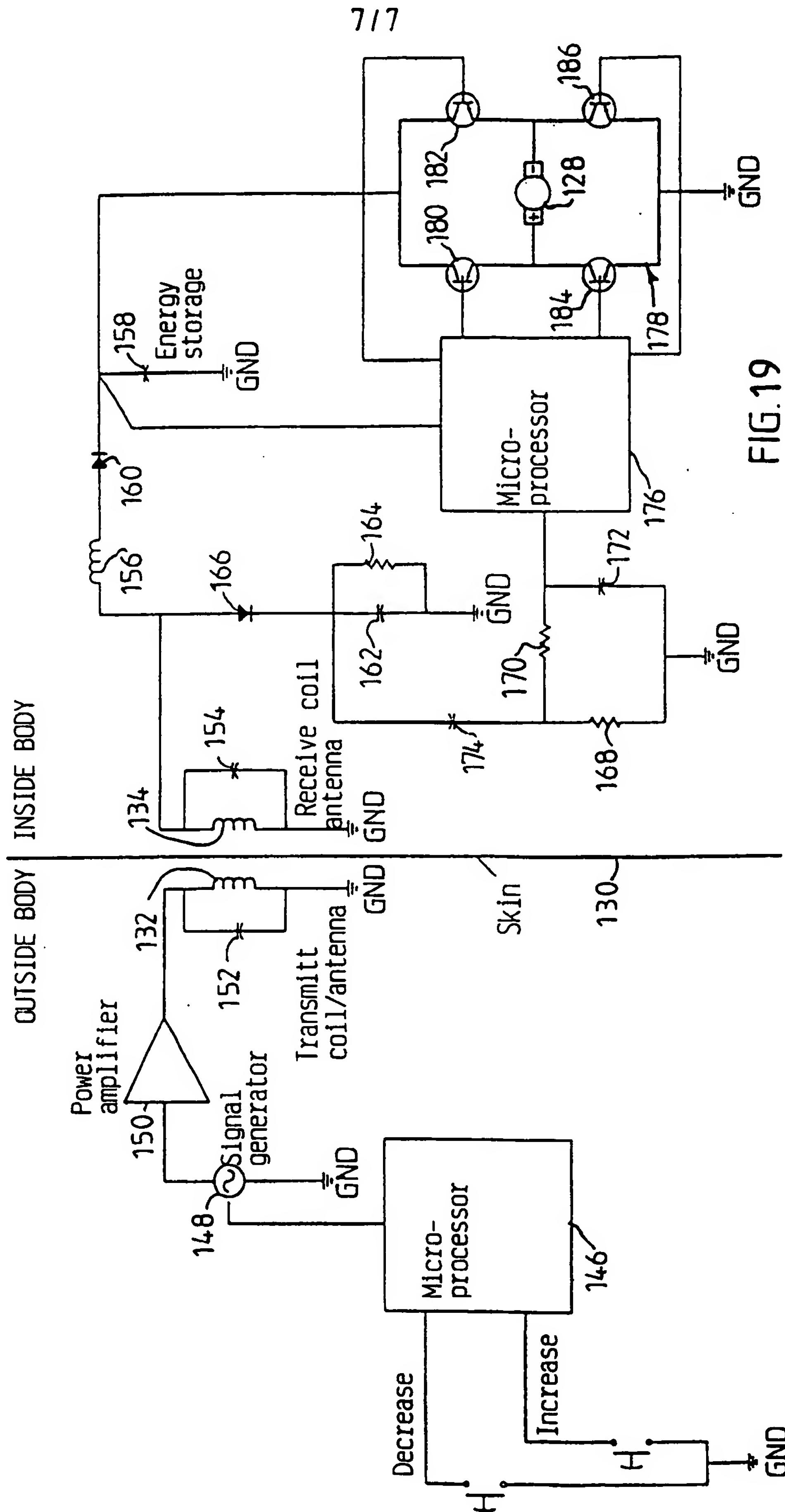


FIG. 19